Morphology and Life-History of the Indian Sann Hemp Moth, Utetheisa pulchella L. (Arctiidae : Lepidoptera), With Observations on the Food Selection Behaviour of the Fully Grown Larva.

ABSTRACT
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By

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This is to certify that Mr. Radhey Behari Mathur has completed his research under my supervision for the Ph.D. degree of the Aligarh Muslim University. His work is a distinct addition in the existing knowledge on the subject and contains some important new observations. He is allowed to submit the work for Ph.D. degree.

(S. Mashhood Alam)
Actg.

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A B S T R A C T

The present study embodies detailed observations on the morphology of the Indian Sann hemp moth, Utetheisa pulchella L. It has been carried out on tagmatal basis. The head capsule contains a few generalised sutures defining certain areas assigned to them. Some of the sutures are either obliterated or completely absent (subgenal suture, occipital suture etc.) with the result that the areas generally defined by them have lost their individual entities. Attempts have been made to distinguish the clypeus from the frons on the basis of muscles which should arise from them. A suture has been discovered to be new for insects and is named as transgenal suture. The name trans-parietal suture is given to a suture which separates the vertex from the gena and its validity has been discussed at length. The cranial appendages and their relative associations with the cranium have been described laying emphasis on their functions. New type of ball and socket like articulations between the scape and the cranium, as well as, between the scape and the pedicel have been recorded for the first time in Lepidoptera. The sucking pump is shown to be exclusively cibarial in nature. A few conclusive experiments have been carried out on the mechanism of uncoiling and coiling of the proboscis. This

confirms the recent theory propounded by Eastham and Eassa (1955).

A comprehensive study of the skeleto-muscular mechanism of the thorax has been done. All the three intertergal plates (phragmanota) have moved backwards to develop sclerotic contiguity with the following terga and are also in membranous connection with the preceding tergal plates. Interesting details on the third thoracic phragmanotum have been recorded. The presence of the tympanal organs in the metathorax has resulted in considerable modifications of the meta-epimera. Several new muscles have been added to the thoracic myology with tentative functions assigned to them.

The abdomen consists of ten segments. It is, arbitrarily, divided into pre-genital, genital and post-genital regions. The pre-genital region consists of the first eight segments; the genital region contains only the ninth segment, while, the post-genital region is represented by the tenth segment. In case of females, the post-genital region is merged with the genital region. Greater emphasis is laid on the external genitalia of both sexes and probable modes of working have been attributed to them. The muscles of the male external genitalia have been placed in three definite categories, viz., indirect extrinsic muscles, direct extrinsic muscles and the intrinsic muscles. The last set of muscles, however, does not exist in the case of female external genitalia. Such categorisation of the muscles has been, for the

first time, proposed in Lepidoptera. The components of the male external genitalia are elaborately represented. Contrary to this, the female external genitalia are highly reduced due to the absence of a typical ovipositor. However, the ninth and tenth segments fuse to form a unit which has assumed the responsibility of egg laying. It is suggested to call such unit as pseudo-ovipositor.

The internal anatomy has been done in considerable details. It is supported, wherever possible, with essential histological observations. The cephalic stomodaeum with its muscles is described. The observations on the subdivisions of the alimentary canal (stomodaeum, mesenteron and proctodaeum) have been made with special reference to the stomodaeal and proctodaeal valves. No peritrophic membrane is formed at any stage of food digestion in the adult. Two types of rectal papillae are described and are here named as mono-papillar and di-papillar types. Two sets of three malpighian tubules each are present. Each set opens by a common duct into the anterior end of the proctodaeum. The dorsal and ventral diaphragms divide the body cavity into the pericardial, visceral and perineural sinuses in the abdomen only. These do not extend into the remaining tagmata. Some interesting observations have been made on the structure and function of the spiracles. Their 'external' and 'internal' closing mechanisms have been clearly demonstrated. The tracheae and the air sacs form a distinct combination in the body of the

moth. The anatomical study of the male and female reproductive organs has been supported with necessary histological facts. The ejaculatory duct is shown to be fairly short. The accessory glands and their common ducts, as well as, the bursa copulatrix have been significantly dealt with. The nervous system, besides the brain and the suboesophageal ganglion, contains six ganglionic masses on its ventral nerve cord; the second and the sixth ganglia appear to be of compound nature. The stomodaeal nervous system does not possess any distinct stomachic ganglion.

The life-history of the moth has been carried out under laboratory conditions. At the same time, some interesting field observations have been made. Some aspects of the adult's behaviour, viz., copulation and oviposition have been studied. Besides, the food selection behaviour of the fully grown larva has been recorded. Cannibalism occurs among the fifth instar larvae. It has, for the first time, been recorded in the Lepidoptera. The results of the experiments on cannibalism show that the truly phytophagous larva, under starvation, takes up entomophagous mode of feeding; but on the availability of the host plant it does not hesitate in returning to its normal phytophagous habit. The external anatomy of the fully grown larva is described with emphasis on the skeleto-muscular mechanism of the cranium. The Dyar's law is found to be applicable on the larvae . The observations on the life-history of the moth are likely to be

of some value to the agriculturists. These may be utilised in planning out the control measures of the pest.

It is regretted that due to great difficulty in procuring good quality of photographic materials, the photostat copies of the diagrams are not very satisfactory. However, the structural representations are there, though these may not be very lively.

Morphology and Life-history of the Indian Sann hemp moth Utetheisa pulchella L.(Arctiidae : Lepidoptera), with observations on the food selection behaviour of the fully grown larva.

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Utetheisa pulchella L.

I N T R O D U C T I O N

The Sann hemp moth (Utetheisa pulchella L.) is a serious pest of Sann hemp crop in India. It is selected for this research project for three reasons: Firstly, it is fairly abundant and easily available all over India. Secondly, the agricultural importance of the pest necessitates the study of its life-history and behaviour. Thirdly, the moth, being a member of the higher group of Lepidoptera, has considerable morphological importance.

The order Lepidoptera has received scanty attention for morphological studies of monographic nature. This does not mean that the lepidopterists have totally ignored this order. There are scattered works available whose importance can not be denied. Ehrlich (1958) and Ehrlich and Davidson (1961) combiningly made a complete monographic study of the skeleto-muscular mechanism of adult Danaus plexippus L. DuPorte (1946, '56) and Snodgrass (1947) have extended, on Lepidoptera, their revolutionary interpretations of the facial area of insect head. Schmitt (1938) has given a detailed account of the mechanism of feeding in Lepidoptera. Recently, Eastham and Eassa (1956) have revolutionised the study of the mechanism of feeding by their new theory based on successful experiments on Pieris brassicae L. Vasudeva (1956) has studied the head capsule of Papilio demoleus L. Srivastava (1957) published his observations on the head capsule of Papilio demoleus L. It is unfortunate that the two authors, working on the head capsule of the same

insect differ considerably. Zaka-ur-Rab (1961) has tried to clear some of the confusions created by the differing views of Vasudeva (1956) and Srivastava (1957). The skeleto-muscular mechanism of the thorax has been thoroughly dealt with by Weber (1924) and Maki (1933) in various representatives of the order Lepidoptera. Recently, Nüesch (1953) and Treat (1956) have published useful observations on the thorax of Telea polyphemus Cr., and Crymodes devastator B., respectively. Srivastava (1961, '62) has worked out the skeleto-muscular mechanism of the thorax of P.demoleus. The external genitalia of the adult Lepidoptera have recently drawn attention of the morphologists. Sibatani et al (1954) and Okagaki et al (1955), combiningly, have made useful observations on the skeletal conditions of the male genitalia of Lepidoptera. Two years after, Klots (1956) published a detailed work on the male and female genitalia of the entire order. Hannemann (1954) is a very useful contribution on the skeleto-muscular mechanism of the genitalia of Argynnis paphia L. Snodgrass (1957) has given a revolutionised interpretation of the structure and working of the male genitalia of Lepidoptera.

The skeleto-muscular mechanism of adult H.pulchella has been studied in considerable details. It is based on Alam's (1960) revolutionary interpretation of morphology, which is evident from his statement, "morphology is a dynamic science and can rightly claim an important place among recent trends in entomology". Recently, this interpretation has been further

strengthened by him (in Press). Efforts have been made to clear confusions by giving new interpretations to certain structures and their functions. The prevalent theory of Eastham and Eassa (1955) on the feeding mechanism has been modified on experimental basis. A new type of antennal articulation has been discovered (Mathur, 1961). Besides, several new muscles are added to the myology of Lepidoptera. The present writer has tried to strengthen his observations by making a wide range of morphological comparisons with important works on Orthopteroid, Hemipteroid and Panorpoid groups, as well as, with classical works on the Hymenoptera. The myology of the external genitalia of both sexes of U.pulchella has been categorised on functional basis. Perhaps, such approach to the lepidopterous genitalia has not, so far, been made.

All the systems of the internal anatomy of the moth have been studied. Their anatomical details have been supported with essential histological observations. Several new findings have been made and a number of anomalies removed. Some features of special interest have been recorded in the digestive, respiratory and male reproductive systems.

The life-history has been carried out under controlled conditions (temperature, 29° C; R.H. 75% ± 5%). Side by side, field observations of important bearing on the life-history have been recorded. Some important aspects of the behaviour of both the moth and its fully grown larva have been studied

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The present writer has come across two important papers just before the thesis was going up for assessment. One of the papers (DuPorte, 1965) deals with the morphology of the facial region in insects with special reference to that of larval Lepidoptera. In this paper, he has not suggested any new interpretation but has reaffirmed his old stand. The other paper (Mortimer, 1965) deals with the anatomy and histology of the alimentary canals of some adult Lepidoptera (feeding and non-feeding forms) and Trichoptera. The present writer has incorporated this work in the present investigations.

with special reference to copulation, oviposition and food selection. These observations might be of some interest to the agriculturists. Further, this trend confirms the need of popularising insect behaviour, in respect to its life-history, as initiated by Alam (1957, '58) and encouraged by Dhillon (in Press). The act of cannibalism among the fully grown larvae, under starved condition, has been, for the first time, reported in Lepidoptera. Some interesting observations have been made on the external anatomy of the fully grown larva with special reference to the mechanism of spinning. The Dyar's Law has been, successfully, applied to the larvae of U.pulchella.

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MATERIAL AND TECHNIQUE

The moths were bred in the laboratory from larvae and pupae collected from Sann hemp fields. These were separately fixed in Picro-chlor-acetic fixative, Bouin's Alcoholic fixative and Petrunkewitsch's fixative and were, subsequently, preserved in 70% alcohol; the first fixative proved to be the best for anatomical and histological studies.

For the study of skeletal system, the material was boiled in 10% KOH. This was followed by rinsing the material in running water. Subsequently, the decolourisation of the material was done by exposing it to chlorine gas, liberated by the action of HCl on KClo3. Finally, the material was

stained with Acid fuchsin or Carbol-aniline; the latter stain gave comparatively better results. For obtaining transparency of the skeletal structures, with muscles stained in situ, the technique, evolved by Alam (1952) and modified by King (1960), was used which gave excellent results.

The material for microtomy was fixed in Picro-chlor-acetic fixative and the sections were cut at 6 μ. Terpineol proved to be a very satisfactory clearing agent, as it, simultaneously, softens the hard tissues. These sections were stained in Heidenhain's Iron Haematoxylin, with necessary use of the mordant, and were counter-stained with alcoholic Eosin.

A C K N O W L E D G E M E N T S

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1. THE HEAD

(i) External Features of the Head Capsule (Figs. 1 & 2).

The dark brownish head of Utetheisa pulchella L., (Indian Sann hemp moth) is of the hypognathous type. When seen from the dorsal side, the facial surface appears a little convex while the gnathal appendages are directed downwards. In outline the shape of the head capsule, when seen from the facial side , is, more or less, like an inverted sub-triangle, having rounded angles. The base of the sub-triangle is represented by the dorsal surface, the two big compound eyes (E) constituting the two sides, whereas, the vertex of the subtriangle is formed by the area whence the coiled proboscis is suspended. The base of the sub-triangle, i.e., the vertex (Vx) is arched upwards and bears the two prominent ocelli (O). The paired antennae are long and many segmented with their sockets (Asoc) located in the upper one-third of the face anterior to the ocelli. The posterior surface of the head is occupied by the large foramen magnum (For) which is divided into two halves by the transverse septum (Tsep) of the postocciput (Poc). The oral fossa is situated ventral to the foramen magnum and is occupied by the maxillae (Mx) and the labium (Lb). The whole surface of the head capsule is clothed with small scales.

(ii) Sutures of the Head capsule (Figs. 1, 2, 19, 24 & 25)

Due to the specialised condition of the head in

U. pulchella, some of the sutures that are found in the head of a generalised insect, are suppressed, and still others are obliterated. However, the following sutures are found.

Laterofacial suture (lfs).---- This suture runs from the anterior tentorial pit (at) to the lower basal angle of the sub-triangular antennifer(a). The suture is not very distinct externally due to secondary sclerotisation of the cranium but its internal ridge (lfr) is fairly prominent and imparts strength to the facial region of the head. This suture has been differently named by various workers. Snodgrass (1935) calls it the 'subantennal suture' although he does not attach much importance to it. Duncan (1939) in Vespula pennsylvanica and Carbonell (1959) in the grasshopper, Marellia remipes Uvarov, following Snodgrass calls it the 'subantennal suture'. DuPorte (1946) showing its morphological significance in different orders of insects names it 'frontogenal suture'. He points out that the anterior tentorial pit lies primarily on this suture but can migrate on it as well. However, DuPorte and Bigelow(1953) have shown in Hymenoptera that due to the ventral descent of the genae, certain other sutures develop, between them and the clypeus, which they name as the 'clypeogenal suture' and which extends between the anterior tentorial pit and the anterior mandibular articulation. Thus the anterior tentorial pit separates the 'frontogenal suture' from

the 'clypeogenal suture'. DuPorte (1956,'57) later on, in the Lepidoptera names this composite suture, thus formed, as the 'laterofacial suture'. The present writer agrees with this name of the suture, as it certainly separates the facial area from the gena. But in U. pulchella as the frons and the clypeus are confluent, the 'frontogenal' and the 'clypeogenal' sutures loose their separate identity. Further, the anterior tentorial pit in U. pulchella lies at the ventral end of the laterofacial suture, close to the oral margin, which, if taken as point of separation of the clypeus from the frons, would amount to confining the clypeus to a small sclerotic area submarginal to the oral margin. This corollarily means that this small sclerotic clypeus should give origin to the dilators of cibarium-a condition not present in U. pulchella- where it is taken as the labrum. The clypeus in U. pulchella, as a matter of fact, is not externally separable from the frons because of of the absence of the frontoclypeal suture (not epistomal suture). However, it must be born in mind that the clypeus and the frons are separable on the basis of the dilators of cibarium and the dilators of the pharynx, as well as, on the location of the frontal ganglion (frGng) coinciding with true mouth.

Srivastava (1957), in Papilio demoleus L., calls this vertical suture, 'oculo-subantennal suture' as he maintains fusion of the 'ocular' and the 'subantennal sutures' by their upper portions. Vasudeva (1956) working on the same insect

regards this as the 'lateral arm of the epistomal suture'. This means that the 'oculo-subantennal suture' and the 'lateral arm of the epistomal suture' can be homologised. But the fact, that epistomal, ocular and subantennal sutures have their own morphological significance shows that there can be no possibility of their homology. Another interesting conflict is about the pleurostomal suture. The course of the pleurostomal suture has been differently shown by the above two workers in P. *gemelgus*. In one case (Srivastava 1957), the 'pleurostomal suture 'starting from the anterior tentorial pit runs ventrally and later on arching over the face between the gena and the 'epistoma', extends downwards to meet the 'hypostomal suture'. In the other case, (Vasudeva 1956), the pleurostomal suture (her subgenal suture) does not start from the anterior tentorial pit, but first runs dorsally and then after arching over the anterior tentorial pit and flanking the pit laterally, goes to the caudal side of the head to be continued as the hypostomal suture. But in fig.3 of her paper, she shows the 'subgenal suture' ending on the ocular suture. Further in the same paper she maintains that the 'lateral arm of the epistomal suture' runs between the antennal socket and the anterior tentorial pit. This means that her 'subgenal suture' does not start from the anterior tentorial pit but from the 'lateral arm of the epistomal suture' dorsal to the anterior tentorial pit. This becomes all the more certain since she does not show any

fusion of the 'subgenal suture' and the'lateral arm of the epistomal suture'. Because of these glaring differences in the fundamentals, in their individual papers, as well as, among themselves, it is better not to comment but to leave it to these workers to come to an agreed conclusion after consultation and re-examination of P. dongleus.

Transparietal suture (TrPrtls): The transparietal suture starts from the postoccipital suture (pos) on the side of the foramen magnum (For). Ascending on the posterior surface, and on reaching the top of the cranium, it descends to meet the upper basal angle of the triangular antennifer (a). The suture has a complete ridge (TrPrtlR). The basal rim of the antennifer has got a small prominent ridge(x) meeting the transparietal ridge dorsally and the laterofacial ridge ventrally. Since the antennal suture is wanting, this small ridge (x) is not the antennal ridge and is definitely a composite suture. To the present writer there appear to be only four possible interpretations of this ridge, viz., extension of the laterofacial ridge upto the upper basal angle of the antennifer; extension of the transparietal ridge upto the lower basal angle of the antennifer; fusion of the laterofacial ridge with the base of the antennifer; fusion of the transparietal ridge with the base of the antennifer. On its course, the transperietal suture flanks laterally the vertex (Vx) as well as, the lateral ocellus (O). Posteriorly the suture cuts off a small subtriangular portion of the parietal which merges dorsally with the vertex. A similar subdivision of the scutum is shown by Alam (1951) in Stenobracon deesa Cam. The remaining extensive portion of the parietal gena is anteriorly subdivided by the

trans genal suture (TrGes) and extends over the posterior surface.

Ehrlich (1968) in Papuus plexippus L., has shown a suture, more or less, of the same course as of the transparietal suture of U. pulchella, and calls it 'paratemporal suture'. He describes another suture-'temporal suture'-which runs parallel but mesal to this 'paratemporal suture'. On reaching the posterior surface of the head it swings inwards to fade off before meeting its counterpart of the opposite side. The area enclosed between these two sutures is the'temporal area'.

Apparently, he follows Ferris (1942) where the latter has shown a single 'sutural system' in a series of insects and calls it as the 'great suture'. Ferris says," It is a system which begins on each side of the head immediately in front of the primary mandibular articulation, forms then a large sinus into which the great ocular lobes of the ocular-antennal segment are received, passes thence to the front of the face where it forms an inverted V above the bases of the antennae". He further says," the premandibular, temporal and postfrontal sutures are parts of a single sutural system. That the system is frequently interrupted by the disappearance of certain portions." According to Ferris (1942) and Crampton(1932),(quoted by Ferris 1942), the 'temporal suture' is the portion of the 'great suture' which runs over the top of the head. It follows then, that the 'temporal suture' is invariably directed

towards the 'premandibular suture'. It may be that, for some reasons, e.g., absence of 'premandibular suture' etc., the direction of the 'temporal suture' slightly deviates from the conventional course to take up a mesally directed path (Ferris 1942; Figs. 17 & 23). The course of the 'temporal suture' as shown by Ehrlich (1958) in D. plexippus appears to be peculiar to the extent of unacceptibility. If the 'temporal' and 'paratemporal sutures' of Ehrlich (1958) as such are accepted, then the 'temporal fossa' of D. plexippus automatically occupies an area which definitely becomes a portion of the mandibular segment of insects as shown by Ferris (1942), whereas, Ferris' interpretation (1942, Fig. 27) logically confines the temporal area to the ocular-antennal segment. Hence, in the opinion of the present writer, the 'temporal suture' in D. plexippus is nothing but a secondary groove. It is further suggested that the 'paratemporal suture' should be taken as 'temporal suture' in D. plexippus and, as such, the area lateral to it will automatically become the temporal area as a portion of the ocular-antennal segment. These suggestions, if accepted, will put D. plexippus in line with Ferris' (1942) conception of cranial morphology.

Ferris (1942) has given a revised interpretation of the insect cranium, and has tried to interpret embryonic segmentation of the head in the head of the image. The interpretation has certainly created great interest and to some extent may be

taken to have galvanised the cranial morphology. However, it has been criticised in some quarters and as yet has not been accepted to have convincingly replaced the conventional morphology of the cranium. As such, the present writer considers it reasonable to stick to the conventional interpretation in U. pulchella, especially when the insect belongs to holometabola where the intervention of a definite pupal stage significantly disturbs the embryonic pattern of morphology.

Vasudeva (1956) in P. demolens calls it the 'postgenal suture' which means that the postgenal area engulfs the conventional occiput, vertex and the upper portion of the facial sclerite upto the antennal socket- a condition not conveniently adjustable in cranial morphology. A suture with almost similar course is labelled as the 'postgenal suture' in Protonarce sexta John., by Madden (1944). But the area laterad to it is claimed by him as 'postgenal' The present writer keeping in view such confusions, proposes the term 'transparietal suture' which is self explanatory and its validity can be explained on the basis of the conventional definition of the parietal.

Postoccipital suture (pos).- The postoccipital suture is incomplete. It appears on the sides of the foramen magnum, but becomes indistinct as it runs down to the posterior tentorial pit (pt). Dorsally, also, it is suppressed due to the unusual pushing of the foramen magnum. Internally the suture develops a prominent ridge (PoR) which bears the insertions of the extrinsic

muscles of the head. Normally the postoccipital suture should have continued upto the posterior tentorial pit, but here it ends before reaching the latter.

Ocular suture.— Surrounding the eye is present the ocular rim (or) along which the cornea can be considered to be in continuity with the facial area. There is no suture submarginal to the ocular rim, suggesting, therefore, that the ocular suture is absent. A distinct internal inflection corresponding to the ocular rim is detectable which, however, cannot be taken as the ocular sclerite deflected from its linear course. This should, also, not be confused with the 'ocular diaphragm' of Ferris (1942).

Transgenal suture (TrGes).— The small oblique transgenal suture runs between the ocular rim and the transparietal suture. It has a weakly developed internal ridge and dorsally subdivides the narrow gena. This suture appears to be a new one as it has not, so far, been recorded in the insect cranium.

(iii) Areas of the Head Capsule (Figs. 1, 2, 3)

Because of the obliteration or absence of certain sutures of the head, the separate identity of some of the areas of the cranium is difficult to define. However, attempts have been made in this direction as shown below.

Frontoclypeus (FrClp).— This is the median somewhat quadrangular sclerite of the face which is bounded laterally by the latero-facial sutures and ventrally by the membranous fold which

suspends the labrum. Dorsally it is continuous with the vertex above the antennal sockets.

The frontoclypeal area has been much disputed and different views have been put forward from time to time. Snodgrass (1935) has primarily given the sutural criterion for defining the frons and the clypeus and has also attached significance to the origin of certain muscles which control the cibarium and the pharynx. According to him, the cibarial muscles always originate from the clypeus, while the pharyngeal muscles take their origin from the frons. Later on, modifying his previous statement, he (1947) ruled out the sutural criterian and emphasised on the myological criterion in respect to the true mouth and the frontal ganglion for defining the frons and the clypeus.

In U. pulchella there appears to be a transverse line on the frontoclypeal plate connecting the antennal sockets. Similar connections have been shown by Madden (1944), Short (1951), Vasudeva (1956), DuPorte (1956,1957) and Ehrlich (1958) in their respective insects. DuPorte (1956,1957) and Ehrlich (1958) take it as the 'transfrontal suture'. On the other hand, Short (1951), Vasudeva (1956) and Madden (1944) call it as the 'median arm of the epistomal suture' and the 'frontal suture' respectively.

The present writer regards it as a mere line of

differentiation of pigmentation and is not prepared to assign any morphological significance to it. As such the frontoclypeal area in U.pulchella is a continuous plate and cannot be subdivided externally into separate clypeus and frons. This is further confirmed by the fact that no pharyngeal dilator muscle arises dorsal to this line of differentiation. DuPorte,however, (1956;Fig.5,No.3a) has shown a pair of dorsal dilator muscles of cibarium arising dorsal to this so called 'transfrontal' suture, and considers this condition as an exception to Snodgrass'(1947) undisputed generalisations. The present writer feels that the question of exception may automatically disappear if DuPorte (1956,'57) agrees to call this so called 'transfrontal' suture as a mere line of differentiation of pigmentation. This would logically mean that at least some element of clypeus is present above this line.

It can now safely be said that the present study on U.pulchella conforms with the generalisations of Snodgrass(1947) regarding myological link between the frons and clypeus with the pharynx and the cibarium respectively. Short (1951) working on Dilina tiliae L., has also confirmed Snodgrass'(1947) generalisation. He is followed by Vasudeva (1956) in P.dimoleus in separating the frons from the clypeus by the socalled 'median arm of the epistomal suture'. But Vasudeva's own statement "It will be recalled that, in point of fact, this is only an apparent line in the present case and is discernible merely because of the

difference in the pigmentation of the frons on the one hand and the clypeus on the other" creates fairly strong suspicion in considering this so called 'median arm of the epistomal suture' as a true suture at all. This doubt becomes all the more deep rooted when Srivastava (1957) in the same insect (P. demoleus) totally denies any such sutural intervention in the region of the so called 'median arm of the epistomal suture' and assigns different ares of the face for the clypeus and the frons. Ehrlich (1958) working on the cranial skeleton of D. plexippus does not accept the so called 'median arm of the epistomal suture' as a separating line between the clypeus and the frons. As a matter of fact, he takes it as 'transfrontal suture'. Ehrlich and Davidson (1961) tried to support their skeletal study of D. plexippus by myology in the same insect. It is evident from their 'fig. 2', that no muscle arises in full or part of it, dorsal to the so called 'transfrontal suture'. Their 'muscle (No-16)' is shown to arise from the so called 'transfrontal ridge' and has been shown as the dorsal most muscle from the facial area to the sucking pump of D. plexippus. Since no muscle of the sucking pump starts dorsal to the 'transfrontal suture' it becomes rather unsafe to consider the area dorsal to this as part of the frons. Thus it is suggested to previous workers who have given sutural status to this connecting line to reconsider their interpretations and fall in line with the present writer in taking it as a mere line of differentiation of pigmentation.

Parietals (Prtl).— The parietal is the lateral area of the cranium bearing the eye and the ocellus. It is ventrally

confluent with frontoclypeus through the vertex; mesally separated from the frontoclypeus by the laterofacial suture, and posteriorly separated from the postocciput by the obliterated postoccipital suture. The two transparietal sutures collectively divide the entire parietal region into three areas on the anterior surface of the cranium (antero-dorsal portion of the vertex and anterior portion of two genae) and four areas on the posterior surface of the carndum (two posterior lobes of the vertex and posterior portions of the two genae).

Vertex (Vx):- The vertex is formed by the dorsal surface of the parietal and is generally called the top of the head as described by Alam (1961) in S. lineata and Snodgrass (1956) in honey bee. Ventrally and dorsal to the antennal sockets, it is confluent with the frontoclypeus. Dorsally it is incompletely separated from the postocciput by the obliterated postoccipital suture. Laterally it is cut off from the rest of the parietal (gena) by the transparietal suture. The two ocelli are located dorso-laterally in the vertex. Vasudeva (1956) in P. dasnolena calls the dorsal surface (top) of the head as the 'vertex' but no where in her illustrations the 'vertex' is labelled, and the so called 'vertex' appears to be occupied by occiput cum frons. Srivastava's (1957) interpretation of the 'vertex' and that of the 'occiput' appears to be conflicting. Ehrlich (1958) in P. plexippus binds the vertex ventrally by the 'transfrontal sutures' a fact in clear conflict with the basic sense of terminology. In the same paper he uses the term 'trans' in the sense of subdividing a certain sclerite,

eg.,'transclypeal band' and 'trans-occipital band'.

Gena (Ge):— The genal area is called the cheek by Snodgrass (1956) in the honey bee. In U.pulchella the gena is present as a narrow sclerite on the anterior surface of the head mesal to the eye, and is extended over the posterior surface in the form of a broad sclerotic area. It is separated from the frontoclypeus by the laterofacial suture and from the vertex by the transparietal suture. Posteriorly it is demarcated from the postocciput by the intervention of the postoccipital suture and from the vertex by the transparietal suture. This unusual close up of the gena with the postocciput is due to the absence of the occipital suture which consequently means absence of the occiput and the post gena. The gena is subdivided by an oblique transgenal suture which separates the major portion of the anterior area of the gena from the rest of the gena. Vasudeva (1956) in P.demolens calls the "lateral areas of the parietals beneath and behind the eyes",as the genae, and the area posterior to the gena as'postgena'. Srivastava (1957) in the same insect, limits the 'genae' to a small triangular sclerite, lying between the eye and the lower portion of the 'epistoma'. Further, he calls the area lateral to the transparietal suture (his occipito-postgenal suture) as the'postgena'and shows it to merge indistinguishably with the'ocular sclerite' on the anterior aspect of the head. The area lateral to the latero-facial suture on the anterior surface of the head is labelled as the 'para-

ocular area' by Ehrlich (1958) in *C.plexinnus*, but the reason for doing so is not clear. The present writer, therefore, considers it as the main portion of the gena. Snodgrass (1956) in the honey bee and Ehrlich (1958) in *C.plexinnus* consider the greater portion of the posterior surface of the head as the 'occiput' though they do not show the presence of the occipital suture. This is, obviously, an old generalised concept inconsistent with the significance of the occipital suture. Ehrlich (1958) in *C.plexinnus* finds a suture running between the posterior tentorial pit and the base of the labium, and calls it 'paralabial suture'. He shows that this suture mesally cuts off a narrow sclerite from the extensive 'occiput' and attributes it to the labial segment. In the opinion of the present writer, at least the ventral portion of the occiput is the postgena which is confluent with the gena in the absence of the occipital suture. With this conception, the 'paralabial suture' of Ehrlich (1958) can be homologised with the conventional hypostomal suture present in a number of insects.

Postoccinut (Poc).— The postoccipital suture sets off a narrow incomplete sclerotic rim from the parietals round the foramen magnum. Dorsally, the postocciput, which is confluent with vertex slightly extends as a semi-circular lobe into the foramen magnum. Close to the postoccipital suture, the lateral wall of the foramen magnum, projects into the foramen magnum and extends to meet its counterpart of the other side, to form a continuous narrow transverse septum (Tsep) which divides the foramen magnum into a dorsal and a ventral half. The

same septum possesses the paired concavities for articulation of lateral cervical sclerites. This location of the paired concavities justifies the origin of the septum from the walls of the foramen magnum. Since the foramen magnum in generalised forms is usually limited by the inner margin of the postocciput (provided the posteccipital suture is present), the transverse septum corollarily becomes a part of the postocciput. This septum has been labelled as the 'tentorial bridge' by Vasudeva (1956) in P. dasnolenus, a fact well removed from the fundamentals of morphology, as the tentorial bridge is always a part of the tentorium.

(iv) Foramen magnum (Fig. 2 &3)

The large foramen magnum (For) occupies the central area of the posterior surface of the head capsule, and its upward extension is responsible for the obliteration of the occiput as detailed earlier. The foramen magnum is divided into two halves as mentioned above, by a transverse septum. The dorsal half provides passage for the alimentary canal and the heart, while the ventral half is traversed by the common salivary duct and the ventral nerve cord.

part not labelled

(v) Proboscidial fossa (Fig. 2) - -

The middle part of the ventral margin of posterior surface undergoes emargination, which results in a bell shaped excavation, called 'proboscidial fossa'. This, as is normal

with insects, provides lodging to the maxillae (Mx) and labium (Lb). The striking feature in U. pulchella, however, is the un-usual upward extension of the fossa, which ultimately becomes contiguous with the ventral half of foramen magnum. Such contiguity, obviously, can be held responsible for the obliteration of sclerotic intervention between the foramen magnum and the proboscidial fossa. The proboscidial fossa, not only contains the maxillae and the labium, but also provides them with suspension from the limiting walls of the fossa.

(vi) Tentorium (Fig.3)

The tentorium braces the cranium from within. It consists of a pair of sclerotic arms stretched from the anterior (at) to the posterior tentorial pits (pt). Since the tentorial pits are retained, the arms can conveniently be seen to arise as their invaginations. The anterior arms (AT) on leaving the slit like anterior tentorial pits, undergo marked dorsal expansion, and the flanges thus formed, fuse anteriorly with the corresponding laterofacial ridges. While posteriorly they are free from the laterofacial ridges but take up a more mesal position. Laterally also, a small flange develops (lfAT). No doubt, it is impossible to limit the anterior or posterior arms because of lack of any sign of the region of their meeting, however, for convenience sake the anterior portion of the arm originating from the anterior tentorial pit, and possessing the dorsal (dfAT), the lateral (lfAT) and the mesal (mfAT) flanges,

has been labelled as anterior tentorial arm. The subsequent portion of the arm, arising from the long oval shaped posterior tentorial pit becomes the posterior tentorial arm (PT). There is no definit body of the tentorium. The posterior tentorial arms, close to their origin, are joined by a transverse bar like, tentorial bridge(TB). The dorsal surface of this bridge is, throughout, fused with the ventral surface of the transverse septum of the postocciput. There are ,however, no dorsal tentorial arms, which have been shown to exist in other insects (*S. dasage*, Ulan 1951 ;*L. migratoria*, Albrecht 1953).

(vii) Antennae with their muscles (Figs. 1,4,5,6&7):—

A pair of long filiform antennae (Ant) arise from the antennal sockets (Asoc),which are located high up on the frontoclypeus, laterally flanked by the combined portion of the laterofacial and transparietal sutures and dorsally limited by the vertex. The rim of the antennal socket (ra) is thickened. It would not be safe to consider it as internal inflexion of antennal suture which is definitely wanting. This contention of the present writer finds support from the works of Snodgrass (1956) on the honey bee, and Srivastava (1957) on *P. dimolenus*. A subtriangular, pivot like process,'antennifer'(a) with bluntly rounded apex (a&) is produced from the lateral half of the rim of antennal socket to articulate with the proximal rim of the scape.

Each antenna is composed of fifty four to sixty segmented flagellum (Fl), besides the two basal segments

called the scape (Sc) and pedicel (Pe). Alam (1951) roughly divides the antenna into a 'basal stalk' composed of the scape only, and the 'distal shaft' consisting of the pedicel and the flagellum. This system has been incorporated in the present study for convenience purposes.

The scape (Sc) is the the largest segment of the antenna. It is cylindrical and undergoes gradual broadening in proximo-distal direction. The base of the scape is suspended from the rim of the antennal socket through the'antacerium' . Laterally the proximal rim (rs) of the scape develops a subtriangular shelf like projection, which articulates with the antennifer, and is the only sclerotic articulation of the antenna with the cranium. This projection may be called as 'articular process of the scape'(b). The under surface of this articular process is concave (b'). The antennifer, being distinctly ventral to the articular process, fits into the concavity of the latter to enforce antennal articulation with the cranium. Such special type of 'ball and socket' like articulation has not so fnr been recorded in Lepidoptera. (Ehrlich,1958; Madden,1944; Srivastava,1957; Vasudeva,1956 etc.)

The broad distal rim of the scape is comparatively feeble and possesses a pair of lateral articular knobs(d). The articular knob is not of usual conical shape and is almost uniformly thickened with the result that its apex is fairly wide.

The inner surface of the apex is cup shaped (f) in the middle to provide proper articulation to the pedicel with the scape. Similarly, the corresponding portion of the proximal rim of pedicel develops a pair of strong inwardly directed articular knobs (e) whose pointed apices (e) are bent outwards to fit into the concavity of the corresponding articular knob of the scape to enforce the only sclerotic articulation of the pedicel with the scape. The rest of the distal rim of the scape is in membranous connection with the proximal rim of the pedicel. Such special type of 'ball and socket' like articulation of the pedicel with the scape is for the first time recorded in Lepidoptera (Ehrlich,1958;Madden,1944; Srivastava,1957 & Vasudeva,1956). Further, it can be said that this type of articulation between the scape and pedicel amounts to a distinct addition to our knowledge of antennal morphology of insects.

The distal shaft consists of fifty three to sixty segments. The proximal most among them is the pedicel (Pe), which is cylindrical. Laterally, the wall of the pedicel encroaches slightly over the corresponding portion of the scape. The feebly thickened proximal rim of the pedicel develops a pair of lateral articular knobs as detailed above. The distal rim of pedicel is plain.

Musculature of the Antennae.— The antennae are provided with both extrinsic and intrisic muscles. The extrinsic muscles are

the levators, depressors and rotators of the antennae, while the intrinsic muscles are inserted on the pedicel. The movement of rotation is, perhaps, the result of some complicated combination of actions of these muscles.

First levator of antenna (Figs. 8 &19; No.1).— It is a thick, fanshaped muscle. It arises from the lateral flange of the anterior tentorial arm and after ascending in vertical plane, is inserted on the basal rim of the scape, posterior to the articular process of the scape.

Second levator of antenna (Figs.8 & 19; No.2).— It is a thin muscle which arises from the posterior portion of the mesal flange of the anterior tentorial arm. Running in postero-dorsal direction, it gets inserted by a tendon on the posterior side of the proximal rim of the scape, mesal to the first levator. It can be compared with the 'outer levator of antenna', of P. *demoleus* (Vasudeva, 1956) and with muscle No.4 of P. *demoleus* (Srivastava, 1957)

Third levator of antenna (Figs.8 & 19; No.3).— It is the thinnest muscle which arises from the lateral flange of the anterior tentorial arm, mesal to the first levator, and running postero-mesally in between the second levator and the second depressor, is inserted by a tendon on the proximal rim of the scape, mesal to the second levator. This muscle can be compared with 'inner levator of antenna' of P. *demoleus*

(Vasudeva,1956) and with muscle'No.3'of *P. demoleus* (Srivastava, 1957).

First depressor of antenna (Figs. 8 & 19;No.4).— It is the thickest, farshaped muscle, which arising by a broad base anteriorly from the lateral flange of the anterior tentorial arm runs in posterio-dorsal direction for insertion on the anterior side of the proximal rim of the scape, anterior to the articular process of the scape. This muscle can be compared with 'Ist. depressor of antenna' of *P. demoleus* (Vasudeva,1956) and with muscle'No.2'of *P. demoleus* (Srivastava,1957).

Second depressor of antenna (Figs. 8 & 19;No.5).— It is less broad than the first depressor and arises anteriorly from the mesal flange of the anterior tentorial arm, mesal to the origin of the first depressor, and after taking up a mesal course, is inserted on the antero-mesal side of the proximal rim of the scape. This can be compared with '2nd.depressor of antenna' of *P. demoleus* (Vasudeva,1956) and with muscle'No.1'of *P. demoleus* (Srivastava,1957).

The intrinsic muscles are the levator and depressor of the pedicel. As the flagellum is not provided with any muscle, it can be assumed that these muscles, to some extent, control the movements of the flagellum as well. Similar muscles have been recorded by Vasudeva (1956) and Srivastava(1957) in *P. demoleus*.

Levator of the pedicel (Figs. 4 & 9;No.6).— It is a short thick muscle arising from the dorsal wall of the scape, is inserted on the dorsal half of the proximal rim of pedicel. It appears to be made up of three incomplete bundles (a,b,c) which end by a common broad base.

Depressor of the pedicel (Fig.4;No.7).—This is exactly similar to the levator in shape and size with three incomplete bundles. These arise separately from the ventral wall of the scape and are inserted by a common broad base on the ventral half of the proximal rim of the pedicel.

Labrum and Epipharynx (Figs.1,13,19,23 & 25).—

The labrum in U.pulchella is a narrow sclerite suspended through a stretch of membrane from the ventral margin of the facial area. It can conveniently, be split up into a median conical lobe, and two lateral lobular pilifers (Pf), which are profusely plumose. The ventral epipharyngeal (Ephy) wall of the labrum forms the roof of the food meatus (fm). Ehrlich (1958) shows a weakly developed 'clypeo-labral' suture in P.plexippus but the present writer fails to record any such suture in U.pulchella.

The labrum is provided with an intrinsic compressor muscle (No.8) which helps during the feeding. The muscle is composed of parallel fibres, connecting the undersurface of the labrum with the outer (upper) surface of the epipharynx.

(ix) Mandibles (Figs. 1 & 24)

For a long time the mandibles have been reported to be absent in Lepidoptera. Kellog (1893) for the first time reported the presence of paired mandibles in Protoparce. Later on, Tillyard (1923 ; quoted by Imms, 1957) reported functional mandibles in Sabatinca. In Scirpophaga nivella F. Pradhan and Aren (1941) have shown the presence of mandibles with condylar thickenings at their base and also, for the first time, reported the presence of the mandibular adductor muscle in Lepidoptera. This muscle is shown to arise near the ventro-posterior corner of the 'ocular ridge' and to converge to a fine tendon, which passing forwards lateral to the muscles of the maxilla is inserted at the outer angle of the mandible. In P. brassicae a pair of reduced mandibles incorporated in the head capsule, has been reported by Eastham & Essa (1955). Recently, Vasudeva (1956) and Srivastava (1957) have shown that the mandibles are totally absent in P. demoleus.

In U. pulchella the vestigial mandibles (Md) are represented by small triangular areas behind the pilifers. These can, however, be distinguished from the genal areas by a faint obliterated line of flexion (Y). However, no extrinsic muscle could be recorded. It is further, suggested that these vestigeal mandibles are non-functional. The presence of vestigeal mandibles in Lepidoptera finds support in the developmental study of Essa (1963) on P. brassicae where the mandibles are taken as immovable vestiges incorporated into the head capsule.

(x)<u>Maxillae with their muscles</u> (Figs.2,10,11,12,13,14,15,16,17,18& 19).--

The maxillae (Mx) are highly modified and are implanted in the proboscidial fossa having continuity with the ventral margin of the posterior surface of the head capsule. These flank the labium (Lb) on sides and their mesal margins are in membranous continuity with the lateral margins of the labium. Each maxilla is composed of a small cardo (Cd), a tubular stipes (st),a long coiled galea (Ga) and a short unsegmented palp(MxPlp). The lacinia is absent.

The cardo (Cd) is a triangular sclerite which is divided into two by a line of flexion. The proximal portion is subtriangular and heavily sclerotised. It is fused all along its lateral margin with the mesal margin of gena; while its mesal margin has secondarily developed sclerotic contiguity with the proximal portion of the lateral margin of labium. The distal portion of cardo is roughly oblong and runs over the proximal end of stipes.

Each stipes (st) is a hollow tubular structure whose cavity communicates with the cavity of the head capsule, through the stipital valve (StVlv). The distal end of the stipes is continuous with the proximal end of the galea. Close to and lateral to the base of galea, a short, stumpy, single segmented maxillary palp (MxPlp) covered with hairs arises from the stipes. In fact, the stipes is a flat sclerotised plate (Stf)

with an almost submarginal ridge (q) along its mesal margin. This ridge roughly divides the stipes into a narrow, incomplete mesal portion (Stf) and a broad complete lateral portion(Stt). The latter is regarded as the main body of the stipes, which is involved along with the stipital lateral margin, in the formation of the 'tubular' portion of stipes. The stipital weakly sclerotised lateral margin, assisted with a portion of the main body of the stipes, bends downwards to be followed by upward rise & mesally directed twist to roll over itself. Later on the lateral margin is continued with the respective gena. This unusual twist is responsible to give a 'tubular' shape to the stipes and the lateral margin ultimately forms the 'flap valve'(PstVlv) which functionally does not permit the blood to escape from the stipital lumen to the cephalic lumen when the proboscis is under extension. The mesal margin of the stipes is in membranous continuation with the labium. The stipital submarginal ridge is broad distally and forms a collar round the galeal trachea(tr) and nerve(n) where the later enter the maxilla. This collar prevents the trachea and the nerve from injury that may be caused during feeding. Along the lateral wall of the tubular portion of the stipes is a longitudinally running oblique groove where the cuticle becomes flexible.(Sttf). This allows the stipes to accomodate itself to changing blood pressure with the stipital tube. The galeae (Ga) together form the proboscis with tapering tip. It remains coiled when not in use. The proboscis in certain butterflies, on extension makes an angle at a point about one-third distance from its base. This point has been named the 'knee bend' by Eastham & Eassa(1955)

in P.brassicae. Similar 'knee bend' has been shown by Vasudeva (1966) in P.demoleus. In U.pulchella, however, no such bend is observed throughout the proboscis. The outer wall of the galea is produced into ridges and furrows, which are more numerous on the distal half of the proboscis. The ventrolateral portion of the outer wall of galea possesses a number of stout exocuticular spines (s). The latter are, however, wanting in the apical region of galea, where as, they are few but longer in the basal region. The apposed surfaces of the two galeae (iwGa) are concave and in combination, form a continuous canal which is regarded as the 'salivary-cum-food canal (fc). The basal portion of the canal is exposed dorsally because of non-apposed condition of the galeae. But to maintain continuity of the canal with the food meatus, the exposed portion is secondaringly overhung by the labrum. The middorsal portion of the inner galeal wall (db) is peculiarly chitinised and elastic. This may be compared with the dorsal bar of P.brassicae (Eastham & Eassa, 1955), where it is considered as responsible for the coiling of the proboscis. The base of the galea (Gab) remains almost straight, lacks the surface annulations and does not exhibit coiling action. Where as the remaining portion of the galea is the seat of coiling and uncoiling actions and contains distinct annulations. The galea base possesses a dorso-lateral sclerotised plate (Z) for insertion of basal muscle.

The outer wall of the galea consists of alternating

sclerotised (exc) and non-sclerotised (end) annuli, which render the galea flexible. The sclerotic annuli are irregular in sclerotisation in the sense that some of them are incompletely sclerotised. The sclerotised annuli are regularly traversed by oblique narrow non-sclerotised bands (NScIb). This feature is for the first time recorded in Lepidoptera. The almost entire sclerotisation of the outer wall is found in the apical portion of the galea. But this condition is replaced in the middle portion of the galea by the intervention of small dorsal and ventral non-sclerotised patches, connecting the outer wall with the inner wall. Further, towards the base the entire wall becomes non-sclerotised excepting two prominent sclerotic patches on its ventro-lateral and ventral portions. It is presumed that the sclerotised annuli mentioned above represent the exocuticle while the non-sclerotised annuli are endocuticular in nature. This is is confirmation of the findings of Eastham and Eassa (1955).

The inner wall of the galea (iwGa) is heavily sclerotised with the result that it is comparatively more rigid than the outer wall. It is also provided with exocuticular annuli but these are regular, complete and closely lying. The exocuticular annuli are intervened by endocuticular annuli. Dorsally the exocuticular annuli fuse with each other to form a continuous sclerotised bar, called by Eastham and Eassa (1955) as the 'dorsal longitudinal bar'

(db), which traverses the whole length of the galea. In the basal region of the galea, where the food canal becomes an open gutter, the'dorsal longitudinal bar' is missing, although the exocuticular and endocuticular annuli are regularly present. It may be taken as an explanation for the fact that the galea base does not participate in the coiling process of the proboscis. Ventrally the exocuticular bars become knobbed. Each knob is provided with one toothed hook (vh). The two galeae are held together by means of dorsal and ventral interlockings formed by the dorsal and ventral portions of the inner wall. The dorsal linkage is not so rigid and firm as ventral linkage. It consists of distally directed plates (dpl) overlapping each other and arranged in a single row. These plates are born by the 'dorsal longitudinal bar'. Although these plates do not lock into each other, yet they form a complete roof over the food canal. This arrangement of the plate allows for the changes that the proboscis undergoes during feeding, and during the coiling and uncoiling actions of the proboscis, without allowing for any sort of leakage of the liquid food.

The ventral linkage is much more rigid and consists of toothed, curved and closely placed hooks (vh) which lock into each other from the opposite side. The hooks are fixed into the exocuticular bars of the inner wall but endocuticle intervenes between the base of the hook and the exocuticular bar. This intervening patch of endocuticle affords freedom of movement to the hooks and allows for the changes that the proboscis undergoes

during feeding and during coiling and uncoiling actions. The hooks of one side fit so closely with those of the other side that no space is left. Such a tight fitting of the hooks checks any sort of leakage of the food from the food canal. The broad base of each hook is provided with an incurved tooth (t).

Muscles of Maxillae

There are extrinsic and intrinsic muscles in the control of the function of the proboscis. The extrinsic set consists of three pairs of muscles, while the intrinsic set consists of oblique muscles of the galea.

Extrinsic muscles:

First adductor of stipes (Figs. 19; No. 9).— This extrinsic muscle arising on the ventral surface of the dorsal flange of the anterior tentorial arm, is inserted by a broad base on the posterior portion of the submarginal stipital ridge. This muscle corresponds with the 'anterior tentorial adductor' of P. brassicae (Eastham & Eassa, 1955), the 'anterior tentorial stipital adductor' and the 'tentorio-juxta stipital muscle' of P. dasoleus (Vasudeva, 1956; Srivastava, 1957)

Second adductor of the stipes (Fog. 19; No. 10).— The second extrinsic muscle is fan shaped and originates on the ventral surface of the antarior tentorial arm. Its fibres end by a broad base on the anterior portion of the submarginal stipital rigde. It is homologous with the 'posterior tentorial adductor' of P. brassicae (Eastham & Eassa, 1955), the 'posterior tentorial

stipital adductor' and the first 'tentorio-stipital muscle' of P. demoleus (Vasudeva,1956; Srivastava,1967)

Third adductor of the stipes (Fig.19;No.11).— This is the broadest muscle of the series and arises on the anterior portion of the gena. The fibres running almost parallel are inserted on the submarginal stipital ridge, limited anteriorly and posteriorly by the second and the first adductors of stipes respectively. Eastham & Eassa (1955) show this muscle to arise from the gena and the clypeus but maintain it as a single muscle and call it the 'cranial adductor muscle'. Vasudeva (1956) finds this muscle to arise from the clypeus and calls it the 'cranial adductor muscle'. In the same insect Srivastava (1967) records it to start from the gena and the fronto-clypeus and consequently splits it into two separate muscles('geno-stipital' and 'cranio-stipital'muscles).

Intrinsic muscles:

Elevator of the galea(Figs.13 & 14;No.12).— This is the first set of intrinsic muscles and is composed of two distinct bundles. One(a) of the bundles is large and arises on the junction of stipes with the galea. Running obliquely, its fibres converge to end on the dorso-lateral sclerotised plate of the galea base. The second bundle (b) takes its origin on the ventral wall of the galea base slightly distal to the origin of the former bundle. It runs obluquely in a convergent manner to get inserted close to the insertion of the first bundle. On contraction, this muscle lifts the galea base upwards and brings it very close to the under-

surface of the labrum, so as to afford an opportunity to the latter to temporarily roof over the otherwise open portion of the food canal. This muscle corresponds to the 'flexor of galea' of generalised insects. In P.brassicae Eastham & Eassa (1955) also show it to be made up of two bundles and call them as 'dorsal' and 'Ventral' elevators of the galea base.

Oblique intrinsic muscles of the galea (Figs.15,16,17,18; No. 13).— The oblique muscles run throughout the length of the galea, arising by base on its mid-dorsal longitudinal line. Running obliquely in dorso-ventral direction, the fibres are inserted on the midventral longitudinal line of the ventral wall of galea. These muscles are comparatively large and more straight in the proximal region. Their contraction assists in the uncoiling of the proboscis by bringing the dorsal and ventral walls closer. In the normal coiled condition of the proboscis, these muscles are relaxed and curved. When the proboscis is uncoiled the muscles contract and become straight. Similar oblique muscles have been reported by Eastham & Eassa(1955) in P.brassicae, Vasudeva (1956) and Srivastava (1957) in P.demoleus respectively.

(xi) Labium with its muscles (Figs. 2, 20 & 21).

The subtriangular labium (lb) is mostly membranous. Its sclerotisation is limited to small areas around the base of the labial palps (LbPlp) and the apex whereas, its middle portion is semi-sclerotised (Sscl). Proximally, the labium is in

continuation with the neck membrane. The sclerotised apex is trifid (tA) and is fused with the hypopharynx. At the junction of the labium with the hypopharynx, is the terminus of the common salivary duct. The labial palps arise from their sockets (Lbsoc) which are situated basally on the sides of the labium and are three segmented. The basal segment is the largest, while the apical one is the shortest. The labial palps are covered with bristles all over.

The myology of the labium has undergone great reduction. This can be ascertained from the fact that only one pair of intrinsic muscles is present. This may be taken as the levator of the palps (No. 14). It arises from the basal sclerotised portion of the labium. Running in meso-lateral direction, it ends on the postero-lateral angle of basal rim of the palp (rLbPlp). The other two segments are devoid of muscles and move along with the basal segment.

(xii) Hypopharynx (Figs. 3, 22, 23, 25 & 26).

The hypopharynx (Hphy) in U. pulchella is highly slerotised and shapes like a shallow triangular bowl. The anterior angles of the ventral wall are modified into a pair of small, triangular, better sclerotised plates (HS). The anterior angle of the plate extends into a ridge (HRA) which is fused with the corresponding genal area of the head. Likewise, the ventral angle (HRV) dives down to be soldered with the apex of the labium. These two points serve the purpose of suspension of the hypopharynx with in the head

capsule. The common salivary duct (sld) passes in between these plates to open by an orifice (slo) at the anterior end of the hypopharynx. The common salivary duct, before its opening, is slightly dilated. This dilated portion of the duct is regarded as the 'salivarium' (slv), as is maintained by Alam (1951) in S. deesae. The ventral half of its orifice (sloV) is sclerotised, while, the dorsal half (sloD) is membranous. Similar condition exists in other Lepidoptera, e.g., P. brassicae (Eastham and Eassa, 1955), P. demoleus (Vasudeva, 1956; Srivastava, 1957). A pair of dilator muscles (No. 15), arising from the triangular plate of the hypopharyngeal ventral wall, is inserted on the roof of the salivary orifice. This muscle is broad at its origin and converges at its insertion. A similar pair of muscles is shown by Eastham and Eassa (1955) in P. brassicae, and by Vasudeva (1956) and Srivastava (1957) in P. demoleus. Alam's (1951) 'anterior dilators of salivarium' can be compared with the dilator of salivarium in U. pulchella.

(xiii) Sucking Pump with its muscles (Figs. 19, 23, 24, 25 & 26).

In U. pulchella the sucking pump (SP) is the modified 'cibarium' of the generalised insect. It is expanded with its dorsal (sPr) and ventral walls contributed by the membranous epipharynx (Ephy) and the dorsal sclerotised surface of the hypopharynx (Hphy) respectively. Posteriorly, the wide sucking pump tapers into a small passage which connects it with the pharynx (Phy). Anteriorly, as well, the tapering connection

exists to put the pump in continuation with the food canal through a short orifice. The present writer maintains that the posterior passage is the 'true mouth' (tm) while the anterior orifice becomes the 'food meatus' (fm). The frontal ganglion (frGng) lying over the posterior passage is a further confirmation of the position of the true mouth. Hence, the structure (sucking pump) anterior to the frontal ganglion, is the cibarium. Further, on the sucking pump are inserted the dilator muscles arising from the clypeus, which shows that these muscles are the dilators of cibarium. The floor of cibarium in a generalised insect is formed of the hypopharynx and the roof by the epipharyngeal wall of clypeus (Snodgrass, 1935). The position of the salivary orifice and origin of its dilators is further confirmation of the hypopharyngeal nature of the floor of the sucking pump. The above observations are, however, in contradiction with the views of Schmitt (1938), Eastham and Eassa (1955), Vasudeva (1956) and Srivastava (1957), all of whom maintain that the sucking pump in Lepidoptera is a complex organ composed of the cibarium, buccal cavity and the pharynx.

Muscles of the sucking pump.— The pump is highly muscular and is controlled by dilator and compressor muscles. These can be put into three categories: a) compres or of the food meatus, b) dilators of cibarium, and c) compressors of cibarium.

(a) Compressor of food meatus (Figs. 24 & 25; No.16).— This muscle consists of parallel fibres connecting the lateral edges

of the apical portion of dorsal wall of hypopharynx. Its fibres transversely run over the roof of the food meatus. On contraction, the muscle appears to close the opening of the food meatus. In P. brassicae, Eastham and Eassa (1955) have shown this muscle traversing both the dorsal and ventral walls of the 'cibarial space' and consequently call it 'transverse sphincter'. Since in U. pulchella, this muscle is present only on the dorsal surface of the food meatus, it cannot function as a perfect sphincter. Srivastava (1957) in P. demoleus calls it the 'cibarial compressor'; although, he also considers it in full control of the 'functional mouth'. Thus, it is difficult to accept it as a cibarial muscle.

(b) Dilators of the cibarium.— For convenience purposes, the roof of the sucking pump is, arbitrarily, divided into three regions, which are the distal third, the middle third and the proximal third of the cibarium.

First dilator of cibarium (Figs. 24, 25 & 26; No.17).— It is a very small paired muscle, arising from the anterior region of the clypeus and inserting on the distal third of the roof of the cibarium, posterior to the compressor of the food meatus. This muscle is homologous to the 'clypeal dilator of the mouth' and the 'posterior clypeo-cibarial muscle' of P. demoleus, recorded by Vasudeva (1956) and Srivastava (1957) respectively. However, Eastham and Eassa (1955) donot find any such muscle in P. brassicae.

Second dilator of cibarium (Figs. 24, 25 & 26; No.18).— This is the median unpaired dilator of cibarium and is similar to the first dilator of cibarium. It arises from the anterior region of the clypeus and is inserted on the distal third of the roof of the cibarium, posterior to the insertion of the first dilator of cibarium. It is homologous to the 'anterior cibarial dilator' of P.brassicae (Eastham & Eassa,1955)

Third dilator of cibarium (Figs. 24, 25; No.19).— This muscle is larger than the first two dilators of cibarium. It arises on the sides of the clypeus very close to the latero-facial ridge and running in latero-anterior direction, is inserted on the middle third of the roof of the cibarium. It can be compared with ' lateral cibarial dilator' of P.brassicae (Eastham & Eassa,1955). In P.demoleus, Vasudeva (1956) and Srivastava (1957) call it the 'dilator of buccal region' and 'subantenno-buccal muscle' respectively. As this muscle is inserted far anterior to the true mouth of the generalised insect the present writer regards it as the dilator of the cibarium and not the dilator of the buccal region. Further, it is difficult to understand how Vasudeva (1956) and Srivastava(1957) have independently taken this region as the buccal cavity which normally is the part of the stomodaeum.

Fourth dilator of cibarium (Figs. 24 & 25; No.20).— It is the thickest and posterior most pair of dilators of cibarium. It originates partly on the rim of the antennal socket and partly on

the dorsal portion of the latero-facial ridge. Descending obliquely and directed anteriorly it is inserted on the proximal third of the roof of cibarium. It is homologous with 'clypeal dilator' of P. demoleus (Vasudeva,1956).

(C) Compressors of Cibarium.— The compressor muscles comprise of paired dorsal oblique, unpaired dorsal transverse and unpaired ventral transverse muscles.

Dorsal oblique muscle (Fig. 24; No. 21).— This muscle starts from the antero-lateral region of the cibarium and running diagonally gets inserted on the posterior region of the cibarium. The two muscles are made up of parallel fibres and cross each other in the form of a 'chiasma'.

Dorsal transverse muscle (Fig. 24; No. 22).— It is also made up of parallel fibres running transversely over the proximal half of the roof of the sucking pump. The fibres connect the sides of the cibarium and are dorsal to the oblique muscle.

Ventral transverse muscle (Figs. 23 & 25; No. 23).— The fibres of this muscle start from the mid-longitudinal line of the ventral surface of the hypopharnyx. Running parallel and across the hypopharynx the fibres end on the lateral wall of cibarium.

(XIV) Cephalic stomodaeum (Fig. 25).—

The part of the alimentary canal lying within the

cranium and posterior to the true mouth is the pharynx (Phy), which is in continuation with the oesophagus. The present writer does not find any morphological difference between the pharynx and the oesophagus, but for the sake of uniformity with other works and for the sake of descriptive conveniences, it is visualised that the part of the alimentary canal confined to the cranium is the pharynx and its posterior continuation in the thorax is the oesophagus. Pharynx being a part of the alimentary canal is provided with the usual muscular sheath. This muscularis of pharynx has been called the 'posterior sphincter' by Easthom and Eassa (1955) and the 'pharyngeal compressor ' by Srivastava (1957). However, in U. pulchella, it is controlled by dorsal, lateral and ventral dilators.

First dorsal dilator of pharynx (Figs. 24 &25; No.24).— It is a paired dilator of pharynx, arising on the frons in between the two antennal sockets and descending anteriorly is inserted on the pharynx posterior to the frontal ganglion and encircled by the frontol ganglion connective. It can be compared with the 'dilator of pharynx' and the 'fronto-pharyngeal' muscle of P. demolous as described by Vasudeva (1956) and Srivastava (1957) respectively. It appears to be homologous with the 'first frontal dilator of anterior pharynx' of S. deesa (Alam,1961).

Second dorsal dilator of pharynx (Figs. 24 & 25; No.25).— It is the unpaired dilator of pharynx arising from the frons mesal to the first dorsal dilator of pharynx and is inserted on the pharynx posterior to the frontal ganglion and mesal to the

insertion of the first dorsal dilator of pharynx. It can be compared with the 'median pharyngeal dilator' of P.brassicae (Eastham and Eassa, 1955) where it is shown to arise from the middle of the clypeus, a condition of origin difficult to understand.

Lateral dilator of pharynx (Figs. 23 & 25; No.26).— It is a single pair of small muscles arising by a broad base on the inner face of the tentorial bridge to get inserted by a long tendon on the lateral wall of pharynx. No such muscle has, so far, been reported in Lepidoptera. It appears to be homologous to the 'first ventral dilator of anterior pharynx' of S.desaae (Alam, 1961) and to 'parietal contractor of the pharynx' of the honey bee (Snodgrass, 1942).

Ventral dilator of pharynx (Figs. 23 & 25; No.27).— It is a single muscle which arises by a broad base on the tentorial bridge mesal to the origin of the lateral dilator of pharynx, and is inserted by a long tendon on the junction of the ventral wall of cibarium (hypopharynx) with the ventral wall of pharynx. This muscle has also not been reported in Lepidoptera (Eastham and Eassa, 1955; Vasudeva, 1956; Srivastava, 1957, 1961). It appears to correspond with the 'posterior dilator of anterior pharynx' of V.pennsylvanica (Duncan, 1939), the 'posterior contractor of the pharynx' of the honey bee (Snodgrass, 1942) and the 'second ventral dilator of anterior pharynx' of S.desaae (Alam, 1961).

(xv) Mode of feeding ...

The food of the butterflies and the moths chiefly consists of nectar, which is sucked up by the sucking pump and then pushed up into the pharynx. In order to reach the sucking pump, the food has to pass through the food canal of the proboscis. Thus, the first step in the feeding is afforded by the complicated mechanism of the extension of the normally coiled proboscis.

There has been considerable difference of opinion on the uncoiling and the coiling mechanisms of the proboscis of Lepidoptera. These difference of opinions are the result of incomplete and defective observations on the structure of the organs concerned. For example, Burgess (1880), Snodgrass (1935), Portier (1949; quoted by Eastham and Eassa, 1955) and Bourgogne (1951) find that the outer wall of the proboscis is provided with and rendered supple by the chitinous annuli, which alternate with the membrane. Weber (1933) points out the presence of the exocuticular rings, but does not mention about the intervening annuli. Pradhan and Aren (1941) have differentiated between the exocuticular and endocuticular rings and find that the proboscis is comparatively more flexible in the distal region. Eastham and Eassa (1955) give a detailed account of the structure of the proboscis in P. brassicae. They find that the outer wall of the proboscis is provided with alternating annuli of exocuticle and endocuticle which impart flexibility to the proboscis. The

inner wall is comparatively more rigid and consists of exo-cuticular lamellae arranged in a large series of bars. These bars are associated with linkages of the proboscis. They have, for the first time, laid emphasis on the ventral and dorsal linkage mechanisms of the galeae. The dorsal linkage is comparatively less firm and is made up of cuticular plates; whereas, the ventral linkage consists of curved toothed hooks, which lock into each other from the two sides.

Such discreponcies in the structure of the proboscis have led different workers to give different interpretations on the mechanism of uncoiling and coiling. Reaumer (1734; quoted by Eastham and Eassa, 1955) was the first man to suggest that the proboscis extends due to the action of muscles antagonistic to the other muscles which coil it. Burmeister (1832; quoted by Eastham and Eassa, 1955) described two series of intrinsic muscles arranged in two sets; the upper set was shown to be responsible for the extension of the proboscis. Later on, Burgess (1880), Lameere (1938; quoted by Eastham and Eassa, 1955) and Bourgogne (1951) suggested that the proboscis uncoils due to its elasticity. However, Kirbach (1884; quoted by Eastham and Eassa, 1955), Hering (1926; quoted by Eastham and Eassa, 1955), Weber (1933) and Pradhan and Aren (1941) disagreeing with the above workers, again took up the idea of Burmeister (1832) and showed that the muscles alone uncoil the proboscis. Snodgrass (1935) compared the uncoiling of the proboscis with inflation of

a'toy paper' snake, and suggested blood pressure as chiefly responsible for the uncoiling mechanism. This view was, later on, confirmed by Schmitt (1938) who gave a comparative account of the feeding mechanism in the various families of Lepidoptera. According to him, the stipital muscles indirectly affect the extension of the proboscis by increasing blood pressure within the galeae, which become airtight cylinders, due to the action of the 'stipital valve'. Eastham and Eassa (1955) have described in detail the mechanism of coiling and uncoiling of the proboscis in P.brassicae. According to them, "primary intrinsic muscles of the proboscis, under conditions of hoemocoelic turgidity maintained by a stipital valve, have effect in producing a dorsal convexity of the proboscis. Extension is a consequence of this dorsal convexity in an elastic system and only indirectly of the contraction of the intrinsic muscles. Assisting in the production of this changed shape of the proboscis, as seen in transverse sections, are the longitudinal internal septa which control the degree of the movement of the proboscis walls and the strong wall of the food tube which acts as a fulcrum on which the movements of the outer galea wall are made."

Equally diverse views have been put forward regarding the coiling mechanism of the proboscis. Long ago, Reaumur (1734) expressed the view that the ring muscles coil the proboscis. Later on, Savigny (1816; quoted by Eastham and Eassa, 1955)

showed that Reaumur confused the cuticular annulations with the ring muscles, and suggested that the cuticular rings on the surface of the proboscis are responsible for the coiling of the proboscis. Burgess (1880) suggested that the basal muscle, as well as, two sets of intrinsic muscles arranged in a series of overlapping 'V's in each galea tend to coil it. Eltringham (1923; quoted by Eastham and Eassa, 1955), Lameere (1938), Snodgrass (1935) and Bourgogne (1951) have all attributed the coiling function of the proboscis to the action of intrinsic muscles. Burmeister (1832) showed that the lower set of muscles coil the proboscis. Kirbach (1884), Hering (1926), Weber (1933), Pradhan and Aren (1941) and Eastham and Eassa (1955) disagreeing with the contention of the above workers pointed out that the muscles have nothing to do with the coiling mechanism of the proboscis. It is the elasticity of the proboscis wall which coils it. But no worker ever tried to find out the exact portion of the proboscis in which the elastic properties rest. It was only Eastham and Eassa (1955), who after performing some experiments, concluded that the dorsal portion of the inner galeal wall is provided with an elastic bar, which they name as the 'dorsal longitudinal bar' and it is in this dorsal bar that the power of coiling is present.

The uncoiling and coiling of the proboscis in U. pulchella are brought about in the following manner:

Uncoiling.— Prior to the extension of the proboscis, the three

adductor muscles of the stipes undergo contraction to effect the closing of the stipital valve. As the muscles contract, the flat part of the stipes is pulled towards its lateral margin, and the two surfaces abut against each other. This is brought about by the straightening of the oblique groove of the tubular part of stipes. Consequently, the passage between the stipital and the cranial lumina is completely closed. The closure of the stipital flap valve turns the stipital lumen into a cylinder closed at its proximal end. This stops the return of the blood into the cranial lumen. Further, the temporary reduction in the area of the stipital lumen leaves the blood with no other alternative but to move under pressure into the galea haemocoele. Thus, the uncoiling is initiated. This is followed by the contraction of the basal muscle of the galea to elevate the galea base, so that, the latter may move towards the labrum to enforce temporary closure of the normally exposed basal portion of the food canal. At this stage the oblique muscles of the galea undergo contraction, to bring the lateral and ventral walls of the galea towards each other. This results in increase in pressure of the enclosed blood, which causes the so far unaffected dorsal wall of the proboscis to undergo straightening. This change can, finally, be held responsible for the complete extension of the proboscis. The cuticular annuli in the wall of the proboscis help in maintaining uncoiled state of the proboscis.

Coiling.— Two experiments were conducted to assure the main cause of coiling.

In the first experiment, the proboscis was separated from the head and treated with 5% KOH solution to dissolve the tissues and muscles of the galea. It was observed that, inspite of complete disappearance of muscles of proboscis, the latter remained coiled. The same proboscis was artificially extended to maximum and then released. The release brings the proboscis back to coiled form. It can, thus, be concluded that the coiling of the proboscis cannot be attributed to the muscles of the galea.

In the second experiment, the KOH treated proboscis was artificially extended. This was followed by chopping off the dorsal portion of the inner galea wall (dorsal bar) along its entire length. The pressure extending the proboscis was withdrawn and it was observed that the chopped off dorsal bar underwent coiling while the remaining portion of the proboscis remained unaffected.

It is, thus, maintained that the dorsal bar is elastic and the power of coiling mainly rests with it. However, it should not be forgotten, that muscles under contraction, when return to their normal form always affect the structures involved. It is, therefore, suggested that the action of the dorsal bar is preceded by slight coiling of the proboscis as a sequence to the return of normalency to its oblique muscles. This

suggestion can be taken as a modification of the 'theory of uncoiling and coiling' advanced by Eastham and Eassa (1955).

To sum up, the theory of uncoiling and coiling of the proboscis put forward by Eastham and Eassa (1955) appears to be most convincing and perfect. The present work is a result of thorough study of the structures, muscles and blood pressure involved in uncoiling and coiling actions supported by a few experiments. The results so acheived show, that the theory propounded by Eastham and Eassa, though quite convincing, still does not appear to be free from some lacunae. In order to improve it and to put it on a more sound footing, the present writer feels to modify it as follows:

(i) The uncoiling is initiated by the temporary reduction in the area of the stipital lumen, caused by the closure of the stipital valve, which forces the blood into the galea haemocoele.

(ii) The basal muscle temporarily closes the normally exposed basal portion of the food canal by abutting it against the labrum.

(iii) The oblique muscles of the galea indirectly affect the straightening of the dorsal portion of the outer wall of the proboscis to cause further increase in the blood pressure. Such straightening is effected by pulling towards each other the lateral and ventral portions of the outer wall of the galea.

(iv) The above stages collectively finalise the complete uncoiling of the proboscis.

(v) The coiling is initiated by the relaxation of the muscles of the proboscis.

(vi) The return of normalency to the oblique muscles helps the dorsal bars to allow their power of elasticity to play the major role in complete coiling of the proboscis.

Ascent of food.— With the extension of the proboscis, its tip is brought into contact with the liquid food. The contraction of the labral compressor enlarges the food meatus. At this stage, the first two dilators of the distal third of cibarium contract to reduce the air pressure of the anterior region of the sucking pump. Such fall in pressure causes the liquid to ascend through the food canal and food meatus to enter into the anterior region of the sucking pump. The subsequent contraction of the third dilator of cibarium, acting on its middle third, results in the arrival of the food in this region of the sucking pump. The fourth dilator of cibarium inserted on its proximal third contracts to allow food to reach this region of the sucking pump. When the latter is full of food , the simultaneous relaxation of the labral compressor and the contraction of the compressor of food meatus, disconnects it from the food canal. Subsequently, the normally closed true mouth is opened, to connect the pump with the pharynx by the contraction of the dorsal, lateral and ventral dilators

of pharynx. The dilators of cibarium now relax in succession in an antero-posterior direction. Simultaneously, the dorsal and ventral compressors of cibarium contract. This exerts pressure on the cibarial food which is pushed up into the pharynx through the temporarily open true mouth. The return of normalcy to the pharyngeal dilators, finally pushes the food further up into the oesophagus. The entire series of actions is repeated till the insect becomes fully fed.

Ejection of saliva.— During feeding, the dilator of the salivarium also comes into action. The alternate contraction and relaxation of this muscle pumps the saliva from the salivarium to the food canal through which it descends to the feeding spot for external digestion of food, before it is sucked up into the pump.

2. THE THORAX

(1) General features of the thorax

In U. pulchella, the thorax is fairly large and is divided into three distinct segments, viz., the prothorax, the mesothorax and the metathorax. These are apposed to each other with very narrow intervening intersegmental membrane. Each segment bears a pair of legs; the mesothorax and the metathorax also carry paired wings and constitute the ptero-thorax. Anteriorly, the thorax is separated from the head by a wide membranous cervical region. Likewise, it is posteriorly in membranous communication with the abdomen. The prothorax is comparatively much reduced while the ptero-thorax, being wing bearing segments, is highly modified and possesses distinct internal ridges. It differs structurally from the prothorax due to the possession of the wings. Laterally, the mesotergum is connected with the mesopleura through membrane excepting the sclerotic continuity of the postalar bridge. The meso and the metaterga are closely approximated with very narrow membrane intervening between them. Likewise, the mesotergum provides a concavity for the protergal stem to articulate with its Thegalmetatergum in the posterior region is in sclerotic continuity with the metapleura due to the appearance of the postalar bridge. The mesopleura and the metapleura are closely apposed to each other and are in sclerotic continuity with their respective sterna . Such peculiarity of association in the various regions of the ptero-thorax, coupled with its dorsal

curvature enables it to withstand the pressure brought upon it as a result of the action of the muscles originating from it.

(ii) The Cervix (Figs. 29, 40 & 41).

The cervix or the neck is, more or less, completely membranous stretched between the rim of the foramen magnum and the anterior face of the protherax. There has been a lot of controversy regarding its true morphological nature. Henry (1958) has recently shown that the cervix of insects is a composite structure formed by the sclerites of the head (belonging to the labial segment), as well as, the prothorax.

In U. pulchella, the neck membrane (cvx) is extensive and the sclerotisation is limited to two arc shaped cervical sclerites (cv) forming a link between the head and the thorax. The middle portion of the cervical sclerite develops a lateral subtriangular projection (cvArkl) which abuts against the anterior margin of the episternum. This subtriangular projection roughly divides the cervical sclerite into proximal (anterior) and distal (posterior) portions. The free end of the proximal portion (cvArkA) is blunt and articulates with the concavity present on the transverse septum of the foramen magnum. The free end of the distal portion (cvArkP) abuts against the corresponding lateral face of the apex of the prothoracic basisternum.

(iii) Structure of the Prothorax (Figs. 27, 28, 29, 30, 31, 32 & 33).

In U.pulchella, the prothorax is comparatively much reduced and has membranous connection with the head. Posteromedially, the protergum articulates with the mesotergum; whereas, laterally it is in membranous connection with the dorsal margins of the propleura. The latter, in turn, completely fuse with the sternum through the precoxal bridge on either side, thereby giving rise to a composite structure, the propectus, functioning as a suspensorium for the prothoracic legs.

Protergum (T1).—

The homologies of the skeletal parts of the protergum are not clear; although, some workers have tried to name them by homologising with the ptero-thoracic plates. The protergum of U.pulchella consists of three plates in the form of a 'y' shaped structure. The dorsal plate forms the stem (T1S) while the lateral plates become the arms (T1A). The basal end of the stem (bT1S) fits into the concavity developed in the middle of the anterior margin of the mesotergum. The side of the apex of the stem has undergone marked concavity to provide membranous connection to the arm. The stem is traversed by a secondary groove (P1) in the apical region and another similar groove (P2) in the middle, which, in the opinion of the present writer have no morphological significance. The

apex of the broad arm is in membranous connection with the propleuron. The thick anterior margin of the arm is followed by a secondary submarginal groove (P3). Dorsally, the arm carries a broad semi-scleritised patagium (pg), the distal portion of which overlaps the neck. The basal lateral angle of the patagium (ArkPg) fits into a shallow concavity (ConFla) present on the dorsal surface of the arm, forming a crude 'ball-and-socket' type articulation. The rest of the base of patagium is in membranous connection with arm. Madden (1944) in P. sexta describes 'parapatagium', as well, which is, however, absent in U. pulchella.

Burgess (1880) divides the protergum of Danaus archippus (milkweed butterfly) on the lines of, and homologous to the tergal subdivisions of ptero-thoracic segments. Schultz (1914), working on Lepidoptera, tries to establish such subdivisions in the protergum. Nüesch (1963), likewise, maintains such subdivisions of the protergum in Telea polyphemus (only in figure; not in text). Burgess (1880), however, in the very beginning of his paper appears to have expressed some doubt on the subdivisions of the protergum: "A slender neck well separated the head from the thorax, whose first somite, or protherax (fig. 1,1) is very small and feebly developed and the homologies of its skeletal parts are not easy to recognise."

The present writer is not prepared to accept such

subdivisions of the protergum, especially when it is an established fact that these subdivisions of a tergal plate are always in respect to the mechanism of flight. This contention finds support from the works of Madden (1944) and Ehrlich (1958) among Lepidoptera. Likewise, no attempt has been made to subdivide the protergum of insects belonging to other orders, e.g., Amblycorypha oblongifolia DeGeer (Kramer, 1944), M. remipes (Carbonell, 1959) Agulla adnixa Hagen (Matsuda, 1956), Leptocorisa varicornis F., (Akbar, 1957), V. pennsylvanica (Duncan, 1939), S. deesae (Alam, 1951) and the honey bee (Snodgrass, 1956).

Further, such subdivisions even in the ptero-thoracic terga are not of consistent nature, as is evident from the study of Diptera (Bonhag, 1952) and Hymenoptera (Duncan, 1939; Alam, 1951; and Snodgrass, 1956), where the metatergum lacks subdivisions and is reduced to a narrow band of sclerite. On the other hand, in Coleoptera (Khateeb, 1946), it is the metatergum which has marked subdivisions as compared to the subdivisions of the mesotergum, because it is the hind pair of wings which is most functional. Furthermore, where both the wings are almost equally functional, the meso- and metaterga, almost equally, have undergone subdivisions as is evident by the present studies on U. pulchella. Similar subdivisions of meso- and metaterga are clearly distinguished in other insects where both the wings are fully functional, as is shown by Kramer (1944) in A. oblongifolia, Carbonell (1957)

in M.remipes, Akbar (1967) in L.varicornis, Madden (1944) in P.sexta and Ehrlich (1958) in D.plexippus.

Propectus.—

There is complete fusion of the propleura with the prosternum. More or less similar fusion is reported in D.archippus by Burgess (1880). Ehrlich (1958) in D.plexippus also shows a fusion but the sclerites involved are slightly different. Alam (1951) in S.deesae appropriately calls this composite structure as 'propectus'. He regards it as a suspensorium for the prothoracic legs:"This structure has no articulation with any part of the insect's body save the head. It is kept in communication with the protergum and the head through membranous connections, and may be considered as 'suspensorium' for the prothoracic legs".

Propleuron

In U.pulchella, the pleuron (Eps) is roughly rectangular forming the side of the prothorax. A portion of the dorsal margin of the pleuron functions as a rest for the ventral margin of the protergal arm. The anterior margin (i) is markedly inflected in the upper portion with a tendency to undergo gradual reduction in dorso-ventral direction. This margin is in membranous connection with the cervical sclerite, as well as, with the head. The ventral margin is not plain and has undergone inverted 'v'shaped emargination to accomodate the trochantin (Tn). The anterior arm of the emargination being

a part of the pleuron extends mesally like a narrow oblique sclerotic plate to fuse with the basisternum (Bs). This may rightly be considered as 'precoxal bridge'(Prex) flanking the procoxal socket (CxC) anteriorly. Posteriorly, the pleuron is limited by a 'line'(Pls) running ventro-dorsally from the ventral to the dorsal margins. It commences on a point in the ventral margin corresponding to the pleural articulation of the coxa of a generalised insect, which is wanting in U.pulchella. This 'line' has a strong internal ridge (PlR) whose ventral half develops a triangular extension (PlA),comparable with the pleural apophysis of other insects, which is fused with pro-sternal apophysis(SA). The present writer regards this 'line' as pleural suture, its internal ridge as the pleural ridge and the triangular extension as the pleural apophysis. No doubt, the pleural pit is wanting, but this is not an unusual condition. Madden(1944) in P.sexta also finds the presence of the pleural suture, its internal ridge and the pleural arm, without any trace of the pleural pit. However, Ehrlich (1958) does not report the pleural suture, or its internal ridge or the apophysis. A condition almost similar to U.pulchella is to be found in the Hymenoptera. Snodgrass (1956), in the honey bee finds that the pleural suture and the pleural arm are present, though the pleural pit is not traceable. Again,in S.dorsata, Alam (1961) shows that the pleural arm is distinguishable in the absence of the pleural pit. The present writer suggests that the absence of the pleural pit may be attributed as a

secondary modification in the anatomy of U. pulchella and such other insects, where identical conditions exist. The confirmation of pleural suture in U. pulchella, therefore, corollarily divides the pleuron into episternum (Eps) and epimeron (Epm). The latter is completely membranous, while the episternum is represented by the pleural plate. Since the epimeron is absent as a typical sclerotic plate, the postcoxal bridge is, likewise, wanting. However, there is a general tendency in the literature on Lepidoptera, that the absence of a typical pleural suture means total absence of epimeron. Burgess (1880) in P. archippus does not show the epimeron in the absence of the pleural suture. Madden (1944) in P. sexta finds that the epimeron is totally wanting though the pleural suture is quite distinct. Again, in P. plexippus Ehrlich (1958) does not divide the pleural plate into the epimeron and the episternum due to the absence of the pleural suture. Puri (1957) shows the presence of 'epimeron' in Chilo tumidicostalis (the sugarcane stem borer) and its connection with the 'postcoxal bridge'. This observation, unfortunately, is liable to mislead since it is not supported by properly labelled diagrams. His micro-photographs do not serve the purpose.

Prosternum.—

The prosternum is much reduced. It contains a pair of distinct apophyseal pits (ap) connected together by a short transverse sternacostal suture(k). Accordingly, the sternum is

divisible into anteriorly placed basisternum (Bs) and posterior furcasternum (Fs). The apophyseal pits lie in a deep external depression in the sternum. The transverse sternacostal suture is internally represented by a weak sternacostal ridge. Similarly, Kramer (1944) in A. oblongifolia divides the 'prosternum' into an anterior 'basisternum' and a posterior 'sternellum', the latter is a composite structure formed by the fusion of furcasternum and spinasternum. However, Snodgrass (1952) has given new terminologies to these plates in P. americana* According to him the 'basisternum becomes the 'antesternite' and the furcasternum is the 'post-sternite'. The basisternum (Bs) is a long and moderately broad sclerotic plate. In the viscinity of the pits it is transversely constricted, while, apically it is in continuation with the procoxal bridge and also provides attachment to the lateral cervical sclerite. It is externally traversed by a mid-longitudinal suture (mvs), which is complete and internally represented by a broad ridge (mvR). The posterior end of the ridge is fused with the middle of the sternacostal ridge and in combination with it forms an inverted 'T' shaped structure, which may be taken to assist the sternum to withstand the stress and strain.

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* Carbonell (1947) studying the morphology of the same insect has retained the names, 'basisternum' and ' furcasternum ' for these regions of the venter.

The suture has been called the 'mid-ventral suture' by Madden (1944) in P.sexta and the 'discrimen' by Ehrlich in P.plexippus. Its internal ridge is named as 'median carina' by Muesch (1953) in T.polyphemus and the 'intercoxal lamella' by Ehrlich (1958) in P.plexippus. Ehrlich (1958) finds a narrow mid-ventral 'presternum' projecting into the cervix. The present writer, however, fails to record the presence of presternum in P.pulchella. Likewise, Madden (1944) in P.sexta, Muesch (1953) in T.polyphemus and Srivastava (1961) in P.demoleus make no mention of it.

The furcasternum (Fs) is an elongated narrow sclerite with wavery sides. It is secondarily traversed by a median longitudinal groove (mlgs) bearing a weak internal ridge. The furcasternum is anteriorly limited bythe sternacostal suture and posteriorly separated from the spinasternum by a faint spinal pit. Madden (1944) in P.sexta shows, more or less, a similar condition, with only one pit as demarcating the furcasternum from the basisternum. Srivastava (1961) in P.demoleus records two 'furcal pits' but makes no mention of the sternacostal suture. Ehrlich (1958) in P.plexippus finds an oval furcasternum with a single 'furcal pit' lodged within it. He seems to have rejected the basic concept of the demarcation of the basisternum from the furcasternum with the apophyseal pits forming the border between the two.

The apophyseal pit (ap) internally develops a tri-

angular sternal apophysis (SA) whose entire upper margin is fused with the lower margin of the corresponding pleural apophysis.

The coxal socket (CxC) in U.pulchella is limited antero-laterally by the pleural elements and mesally by the sternal element (basisternum). But according to Ehrlich's (1958) interpretation of the sternum of P.plexippus, the coxal socket is enclosed from all sides by the pleuron excepting a small mid-posterior area where the furcasternum forms its limit.

The spinasternum (Ss) of U.pulchella is like an inverted 'Y' with the base of the stem possessing the unpaired spinal pit (SpnP). The divergent narrow arms move backwards to fuse with the anterior margin of the mesothoracic basisternum. The base of the spinasternal stem bends upwards to enable its tip to fuse with the tip of the furcasternum borne on a similar upward bend of the latter. The spinal pit invaginates to form a short spina (spn). The latter, extending anteriorly, undergoes secondary fusion with the furcasternum. The spina is an important point for the attachment of the muscles. Shepard (1930) shows a 'Y' shaped spinasternum in several other members of the Superfamily Noctuoidea. Madden (1944) in P.sexta and Nüesch (1953) in T.polyphemus respectively show an internal spina, but make no mention of the pit. Ehrlich (1958) in P.plexippus finds the pit in the middle of the spinasternum.

Similarly, Srivastava (1961) in P.demoleus records the pit located anteriorly on the longitudinal arm of the 'T' shaped spinasternum, which leads into a large 'spina' projecting into the mesothoracic cavity.

Ferris (1950) makes an effort to give a new concept to the pleurosternal region of insect thorax. According to him, the thorax consists of a dorsal plate-'tergite' and a pair of 'limb bases'. The limb bases meet along the mid-longitudinal line of the venter and enclose between them some sternal structures lying on the mid-line and belonging to the definitive sternum. The present writer thinks that this may not, however, be free from exceptions; since Ferris (1950) himself maintains that the sternal elements may as a result of some traceable processes reappear as definite sternal plates. If this three dimensional view of Ferris is applied to the prothorax of P.pulchella, the protergum of the latter with all its subdivisions becomes the 'dorsal plate' and the propectus (pleura and their subdivisions, basisternum and furcasternum) forms the 'limb bases'. The mid-longitudinal ridge, sternal apophysis, apophyseal pit and spina become the sternal elements (discriminal line).

(iv) Structure of the fore-legs (Figs.30, 31, 34, 35, 36, 37, 38, 39 & 43)

The fore-leg is slender and weak and is the shortest of all the legs. The coxal articulation is mainly responsible

for the movement of the leg as a whole. The coxa can be divided into two longitudinal halves (anterior and posterior halves) by an imaginary axis (bb) passing vertically through its thoracic articulation. If the movements of the coxa are watched, with this line of axis in mind, they are found to be forward and backward, specially when the trochantinal articulation has shifted from its normal anterior position to an antero-lateral position. To find out the exact function of the muscles influencing the movements of the leg as a whole, their points of insertion have been studied in relation to the line of axis. The result of this study shows that the muscles are inserted anterior and posterior to this axis, i.e., the muscles are promotors and remotors.

Coxa (Cx).— The coxa is, more or less, subcylinderical in shape and tapers distally. The antero-lateral surface of the proximal rim of the fore-coxa has developed mesally directed inflection (CxArk). The latter develops a small distinct concavity (CxArc) for the trochantinal articulation of its side. The coxal rim (Cxpr) is suspended from the coxal socket (Cxc) by conjunctival membrane. An incomplete submarginal suture called the basicostal suture (bcs) runs slightly distal to the proximal rim demarcating a narrow marginal bacicoxite (Bcx) from the rest of the coxa. The suture is confined to the articular point and extends a little distance along the anterior and posterior portions of the coxal rim; whereas, an incomplete basicosta (Bc) is found. The latter is fairly broad near the coxal articulation.

An incomplete groove (sg) starts from the basicostal suture and runs downwards to a very short distance on the lateral surface of the coxa. This stumpy groove with a corresponding feeble ridge, certainly, under no stretch of imagination reaches the anterior trochantinal articulation, and consequently, should not be confused with a typical 'coxal suture'. Srivastava (1961) in P. demoleus, however, labels a similar groove as 'coxal suture'.

Distally the coxa has dicondylic articulation with the trochanter. Its anterior and posterior angles are produced into internally directed knobs (CxDArk) to articulate with corresponding knobs of the proximal rim of the trochanter; hence, the movements of trochanter on the coxa will be 'up and down'. The rest of the proximal rim of the trochanter is suspended from the coxal rim through a thin conjunctival membrane. The mesal half of the distal rim of the coxa is distinctly emarginated to accomodate the corresponding half of the trochanteral rim during movement.

Trochanter (Tr).— The trochanter is a small curved segment of the leg which articulates proximally with the coxa and distally with the femur. The anterior and posterior (lateral) angles of the thickened proximal rim (TPr) are modified into articular knobs (TrArk) which provide articulation to the corresponding articular knobs of the coxa. The ventral half of the proximal rim is conical and notched in the middle. This receives the

apodemal plate of the depressors of trochanter (vapTr). The usually concave dorsal half of the proximal rim receives on its middle the common apodeme of the levators of trochanter (dapTr).

The articulation between the trochanter and femur is monocondylic, thereby the movements of the femur are restricted. The ventral half of the distal rim of trochanter is deeply emarginated in the form of an inverted 'Ψ' which possesses a small articular knob (TrArk) in its apex. This knob articulates with a corresponding concavity present in the middle of the ventral prolongation of the proximal rim of femur. The dorsal half of the distal rim of the trochanter is normal. Thus, the movements of the femur are restricted to reduction alone controlled by a single reductor muscle.

Femur (Fm).— The cylindrical femur is the longest segment of the leg. It meets with the trochanter along an oblique dorso-ventral course and a narrow conjunctival membrane connects them. The proximal rim of the femur (Fmr) is normal excepting its ventral portion, which is produced to fit into the emargination of the corresponding ventral wall of the trochanter. At the apex of the ventral prolongation is present a small concavity (FmArc) to provide articulation to the corresponding articular knob borne by the distal rim of the trochanter. The posterior half of the proximal rim provides a wide area for the attachment of the apodeme of the reductor muscle of the femur (x).

The ventral half of the distal rim of femur is emarginated (e) while the dorsal half is almost normal. Its lateral angles (anterior and posterior) are developed into articular knobs (DFmLArk) to provide dicondylic articulation to the tibia. Hence, the movements of tibia would be those of extension and flexion in response to the actions of tibial muscles. The space in the articular areas is filled with conjunctival membrane.

Tibia (Tb) .-- It is a narrow slender segment shorter than the femur. The thick proximal rim (Tbr) laterally bears the anterior and posterior articular knobs (TbLArk) to provide the tibial articulation with the femur. The dorsal half of the proximal rim is convex while the ventral half is concave. The broad apodemal plate (dapTb) of the tibial extensor rests at the apex of the dorsal half of the proximal rim. The ventral half of the proximal rim receives the long apodeme of the tibial depressor (vapTb). The ventral surface of the tibia possesses a narrow leaf like structure (Epp), comparable with the 'epiphysis' of P. sexta (Madden, 1944). Basally, this structure fits into a cavity (Eppc) present on the ventral surface of the tibia, while apically, it is free and tapering. This may be taken as incomplete form of the 'antenna cleaner' borne by the mesothoracic leg of S. desesae (Alam, 1951).

The dorsal half of the distal rim of tibia is clearly emarginated and possesses a distinct concavity which provides articulation to the articular knob of the basitarsus. Hence, the

tibio-tarsal articulation is of monocondylic type and the movement of the tarsus is of depression (flexion).

Tarsus (Tar).— The tarsus consists of five distinct tarsomeres, with the basitarsus (Btar) being the longest. The fifth segment is followed by the pretarsus (Ptar). The first four tarsomeres, on their ventral surface, bear three rows of short spines, whereas, the fifth one possesses only two rows of such spines. Dorsally, the proximal rim of the basitarsus is produced into an articular knob to fit into the corresponding articular concavity of the tibia. The proximal end of each tarsomere, except the basitarsus, is narrow and fits into the comparatively broader distal end of the preceding one.

Pretarsus (Ptar).— The pretarsus is the terminal segment of the leg and is articulated with the distal end of the tarsus (Tar). The true, independent segmental nature of the pretarsus as suggested by Snodgrass (1956) in the honey bee is acceptable. Kramer (1944) in A. oblongifolia, considering the terminal position of the pretarsus, points out that this term is inaccurate, since it implies a segment lying before the tarsus rather than after it. He suggests the term 'posttarsus' in place of pretarsus.

The dorsal half of the distal rim of the last tarsomere extends out in the form of a quadrilateral shaped plate (f) which possesses a median (u) and two lateral (unf) knobs. This plate

can conveniently be compared with the 'unguifer' of the Cockroach (Snodgrass,1935)*. Alam (1961)+ in S.dasnae, however, appears to have given a different conception to the 'unguifers'. Snodgrass again (1956)‡ seems to have revised his concept of 'unguifers'. The second view of Snodgrass amounts to a confirmation of Alam's (1961) view, though, the former has not discussed it in his work. The quadrilateral-shaped plate of U.pulchella can be considered as analogous to the'dorsal plate' of the honey bee (Snodgrass,1956). Likewise, the lateral knobs become the 'unguifers' of U.pulchella, which articulate with the corresponding concavities in the base of the claws. The claw (un) is a hollow, strongly sclerotised,elongated structure. Distally it is curved and split up into two pointed hooks. The base of the claws possesses a distinct concavity for the articulation of the unguifer. Similar articulations have been

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* "Each claw is articulated dorsally to the unguifer (A,k), a median process of the distal end of the last tarsomere (Tar)."

+ "The distal margin of the dorsal wall of the last tarsomere develops a crescent-shaped emargination (Fig.61,TarDDR) from the centre of which a sclerite diverges in either direction and parallel to its margin. These are called 'Unguifers'."

‡ "The claws arise from the base of the segment (B),but they are articulated individually on condyles borne on a small dorsal plate (A,f) at the end of the tarsus".

shown by(Alam,1961) and Snodgrass (1956) in S.*gregaa* and the honey bee respectively. The median knob of the dorsal plate receives an elongated sclerotised structure (mn), which is distally attached to the base of the arolium. This plate can be compared with the 'manubrium' of S.*gregaa* (Alam,1961) and the honey bee (Snodgrass,1956). Somewhere in the middle, the manubrium has broadened and possesses a distinct concavity on the dorsal surface. This concavity is the base of a long, thin, cylindrical spine (s), which may be taken as a receptor organ. The arolium (Ar) is the dorsal terminal portion of the pretarsus. It is a large, soft, membranous lobe. The dorsal surface of the arolium is depressed and thrown into longitudinal folds. In the basal half it possesses an incomplete circular narrow sclerotic band (arc) which does not extend over the dorsal surface. This can be taken as homologous to the 'arcus' of S.*gregaa* (Alam,1961) and the honey bee (Snodgrass,1956). The elasticity of the arcus is responsible to bring back the walls of the arolium to normalency, and there by, the extended dorsal surface of the arolium regains its foldings. Madden in P.*sexta* regards the arolium as a simple reduced membranous area dorsal to the empodium and containing a tiny cylindrical spine('orbicula'). Similarly, Ehrlisch (1958) finds the arolium as a simple feebly sclerotised structure,lying dorsal to the empodium.

The thickened ventral half of the distal rim of the last tarsomere (vtar) is deeply emarginated to accomodate the median sclerotised 'unguitractor'(Utr) whose basal one-third is

normally placed within the last tarsomere. The unguitractor is more or less rectangular with the proximal margin deeply concave and receives the long tendon of the 'retractor of the claws'. Just distal to the unguitractor lies a transversely elongated sclerite whose distal margin is deeply concave and can be called the planta (Pln). The latter is in membranous connection with the unguitractor as well as with the arolium. Lateral to the unguitractor the membrane extends forward in the form of a lobe like structure, called by Madden (1944) the 'pulvillus'. Similar lobe like 'pulvilli' are shown by Madden (1944) and Ehrlich (1958) in P. sexta and D. plexippus respectively. The empodium and the auxilliae are wanting in U. pulchella.

The contraction of the pretarsal muscle results in the flexion of the claws, which try to hold the surface unless it is too smooth to be grasped. In the latter case the arolium which forms the chief adhesive organ flattens to grasp the smooth surface.

(v) Musculature* of the prothorax.—

The musculature of prothorax differs considerably with that of the other thoracic segments because of the absence of wings.

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* The myology of the thoracic region has been done by Weber (1924, '33) Maki (1938), Niesch (1953), Ehrlich & Davidson (1961) and Srivastava (1961, 1962) on Papilio, Lepidoptera, T. polyphemus, D. plexippus and P. demoleus respectively. These writers, except-

On functional basis, these can be held responsible for the movements of the head, propectus and legs.

First levator of the head (Fig. 40; No. 28).— This stout muscle originates from the lateral cervical sclerite just anterior to its attachment with the episternum and ascending obliquely is inserted in the middle of the dorsal half of the rim of foramen magnum. This muscle is broad at its origin and tapers towards the insertion. It corresponds with muscle No. 19 of D. plexippus.

Second levator of the head (Fig. 40; No. 29).— A comparatively broad muscle with parallel fibres, it originates from the lateral cervical sclerite anterior to the first levator of the head. Running in an oblique direction and almost parallel to the first levator of the head, it ends slightly lateral to the insertion of the latter. It is similar to muscle 'd4' of T. polyphemus and muscle No. 20 of D. plexippus.

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ing Maki (1938), have neither described the functions of the various muscles nor have given functional names to the muscles. However, to make full use of these works, the present writer has tried to compare these works as closely as possible. Further, in comparing the muscles, only the names of the insects concerned will be given in order to avoid repetition of author's names.

Third levator of the head (Fig. 40; No. 30).— It is a thin muscle which arises at the apex of the protergal stem. It runs lateral to the first and the second levators of the head to get inserted dorsally on the postoccipital ridge. It can be compared with muscle 'd5' of T. polyphemus and with muscle No. 28 of D. plexippus.

Fourth levator of the head (Fig. 40; No. 31).— This muscle is longer and thicker than the third levator of the head. It arises by a broad base on the protergal stem slightly posterior to the third levator of the head. The muscle takes up anteriorly directed course to end on the postoccipital ridge slightly ventral to the insertion of the third levator. It is similar to muscle 'd2' of T. polyphemus, where it is shown to arise on the anterior edge of the 'scutum 1', and to muscle No. 29 of D. plexippus.

Fifth levator of the head (Fig. 40; No. 32).— This is also a thin muscle which arises laterally on the acrotergite of mesonotum (first phragmanotum) and running lateral to the first and second levators of the head, is inserted on the postoccipital ridge ventral to the insertion of the fourth levator of the head. It can be taken as muscle 'd3' of T. polyphemus. Ehrlich and Davidson (1961) in D. plexippus find a similar muscle(No. 32) the origin of which is shown on the lateral edge of mesothoracic prescutum.

Sixth levator of the head (Fig. 40; No. 33).— This muscle

arises anteriorly on the prealar arm of the mesothorax and forms a common insertion with the fifth levator of the head. It can be homologised with muscle 'd1' of T.polyphemus and with muscle No. 30 of D.plexippus.

Seventh levator of the head (Fig. 40; No. 34).— It is a very long thin muscle with more or less parallel fibres. It arises dorsally on the sternal apophysis and passing lateral to all the levators of the head, is inserted on the dorsal half of the rim of foramen magnum ventral to the insertion of the second levator of the head. It corresponds with muscle 'd6' of T.polyphemus and with muscle No. 27 of D.plexippus.

Eighth levator of the head (Fig. 41; No. 35).— This is a thick muscle with parallel fibres originating on the lateral cervical sclerite lateral to the origin of the first levator of the head. Running lateral to the seventh levator of the head, it gets inserted on the postoccipital ridge in very close proximity of the insertion of the third and fourth levators of the head. It can be compared with muscle No. 18 of D.plexippus.

The contraction of all the eight levator muscles pulls the dorsal half of the foramen magnum downwards but the latter's articulation with the cervical sclerites causes it to be raised upwards.

Depressor of the head (Fig. 40; No. 36).— A very large muscle

with broad base originating on the middle of the mesal surface of the sternal apophysis. It is inserted by a short tendon laterally on the ventral half of the rim of foramen magnum. On contraction, this muscle pulls the ventral portion of the head backwards and thereby, makes it bend downwards. The function of the depressor muscle appears to be two-fold; firstly, it brings the elevated head back to its normal position of rest, and, secondly, its further contraction bends the head downwards. It corresponds with muscle No. 24 of L. plexippus. Nüesch (1953) in T. polyphemus shows this muscle (his muscle 'V') as inserted on the ventro-lateral end of the postocciput. The present writer does not consider this region as a portion of postocciput (vide page 14).

Torsion muscle of the head (Fig. 40; No. 37).— This small spindle shaped muscle arises from the episternum anterior to the latter's attachment with the protergal arm. Running almost parallel to the body axis and mesal to all the eight levators of the head, this muscle is inserted on the transverse septum of the foramen magnum, very close to the articulation of the cervical sclerite. On contraction, it bends the head sideways. It can be compared with muscle 't' of T. polyphemus. Ehrlich and Davidson (1961) in L. plexippus show two such muscles (Nos. 21 and 22) both of which arise on the dorsal part of the dorsal arm of the cervical sclerite, and are inserted on the dorsal and ventral parts of the tentorial bridge, respectively. Alam (1953) in S. dessae shows a similar 'torsion muscle ' in the abdomen.

Productor of the head (Fig.41; No. 38).— It is a stout muscle arising by a broad baseon the sternal apophysis lateral to the origin of the depressor of head. Running parallel to the body axis, it is inserted by a small tendon on the lateral cervical sclerite, ventral to the attachment with the episternum. The points of origin and insertion are, more or less, at the same level. On contraction the muscle pulls the posterior portion of the lateral cervical sclerite backwards. This, likewise, makes its anterior portion move forwards and thereby, the head is protruded. It can be compared with muscle No. 26 of P. plexippus, and muscle No. 36 of P. domoleus.

Reductor of the head (Fig. 40; No.39).— It is a spindle shaped muscle arising dorsally on the sternal apophysis of the prothorax very close and ventral to the origin of the seventh levator of head and is inserted on the cervical sclerite immediately anterior to the latter's attachment with the episternum. The contraction of this muscle pulls the anterior portion of the cervical sclerite backwards, thereby, bringing the protruded head back to its normal position. It can be taken as muscle No. 25 of P. plexippus and muscle No.35 of P. domoleus.

First retractor of protergum (Fig.40; No.40).—It is a thin muscle. Arising from the first phragma, lateral to the basal end of the protergal stem, it ascends forwards to end on the apex of the protergal stem. It can be compared with muscle No. 35 of P. plexippus and muscle 'd1' of T. polyphemus.

Second retractor of proterxum (Fig. 41; No. 41).— This muscle is spindle shaped. Arising on the first phragma lateral to the basal end of the origin of the fifth levator of the head, it ascends, like the first retractor of protergum, to end on the side of the apex of the protergal stem. This muscle is not reported in Lepidoptera except muscle No. CIX of Sphinx convolvuli (Berlese, 1909).

Depressor of protergum (Fig. 41; No. 42).— This strong spindle shaped muscle arises on the anterior aspect of the prealar arm. Running ventro-dorsally directed, it ends on the middle of the side of protergal stem. It is comparable with muscle 'd12' of T. polyphemus and muscle No. 34 of D. plexippus.

These three muscles for all practical purposes are undoubtedly inter-tergal (dorso-longitudinal) muscles. As a rule they should be functionally identical but it is interesting to note that the first two (Nos. 40 & 41) are clearly retractors, while the third (No. 42) is distinctly a depressor. Anyway, these three muscles in combination are responsible for the common cause of bringing back the protergum to its normal position, which is likely to undergo slight displacement as a result of head muscles arising on it. The depressor muscle (No. 42) is a very good example of the cause of action of a muscle influencing its function irrespective of points of the origin and insertion.

Anterior levator of propectus (Fig. 41; No. 43).— It is a

long thin muscle which arises on the acrotergite of the mesonotum (first phragmanotum). The fibres run obliquely parallel to each other in an antero-ventral direction to be inserted on the dorsal margin of the episternum, posterior to the latter's attachment with the protergal arm. It is similar to muscle 'pdc' of T. polyphemus.

Posterior levator of propectus (Fig.40 & 41; No.44).— It is a short thick muscle arising on the ventral aspect of the mesothoracic prealar arm and is inserted partly on the pleural apophysis of the prothorax. The muscle descends obliquely, more or less, parallel to the anterior levator of propectus. It corresponds to muscle 'dv' of T. polyphemus and to muscle No.39 of D. plexippus. Nuesch(1953) in T. polyphemus, following Weber (1933), does not consider this muscle as intersegmental,because he regards the anterior surface of the 'prealar arm' as a prothoracic derivative. Snodgrass (1935) maintains that no 'tergosternal muscle' is present in the prothorax. The present writer agrees with him and regards the entire prealar arm as mesothoracic in origin. The muscle corollarily, becomes an intersegmental one.

Since the two levator muscles are inserted at the two extremes of the propectus, their simultaneous contraction changes the position of the propectus by raising it upwards.

First protractor of propectus (Figs.41 & 42; No.45).— It arises on the proximal portion of the protergal arm and descends

obliquely in a postero-ventral direction to end on the pleural ridge. This can be compared with muscle No.40 of P.plexippus and with muscle (Pda) of T.polyphemus.

Second protractor of propectus (Figs.41 & 42; No.46).— This muscle arises by a narrow base on the antero-lateral angle of the protergal stem. Descending in a postero-ventral direction, it is inserted on the pleural ridge, posterior to the first protractor of propectus. It can be taken as muscle 'pdb' of T.polyphemus and muscle No.36 of P.plexippus. The oblique nature of these two protractor muscles clearly demonstrates that on contraction these make the propectus move forwards.

First retractor of propectus (Figs. 40 & 55;No.47).— A very long muscle arising by a narrow base on the anterior aspect of the middle of the mesofurcal apophysis, it is inserted by a broad base on the posterior aspect of the prosternal apophysis. This muscle corresponds with 'Vl' of T.polyphemus and muscle No. 47 of P.plexippus.

Second retractor of propectus (Fig.40; No.48).—A spindle shaped muscle which runs between the dorsal margin of the sternal apophysis and the spina. It can be compared with muscle 'Vl' of T.polyphemus and muscle No.46 of P.plexippus. A similar muscle (No.37) is reported in P.demoleus.

The two retractor muscles combiningly act antagonistic to the protractors of propectus. The contraction of the two retractor muscles brings the propectus back to its normal

position after the relaxation of the protractor muscles.

(vi) Musculature of the fore-legs.

The movements of the fore-coxa are comparatively less restricted than those of the middle and the hind-coxae. The following muscles control the movements of the fore-legs.

Cranial promotor of coxa (Figs. 40, 41 & 43; No.49).— It is a long, thin muscle arising on the transverse septum of the foramen magnum mesal to the occipital concavities, it runs obliquely backwards to get inserted anteriorly on the basicosta away from the trochantinal articulation. The present writer puts it in the category of intersegmental muscles and takes it as one of the rare muscles in insects. Berlese (1909) in S. convolvuli, Ehrlich & Davidson (1961) in D. plexippus and Srivastava (1961) in P. demoleus have reported a similar muscle (muscle No.CXLII of S. convolvuli, muscle No.23 of D. plexippus and muscle No.49 of P. demoleus). It can be taken as a speciality of the Lepidoptera. On contraction it moves the coxa forward and consequently the entire leg is brought forward.

Pleural promotor of coxa (Figs. 41 & 43; No.50).— It is a very thick and fan-shaped muscle arising on the episternum. Running vertically downwards it gets inserted, by a tendon, on the basicoxite in between the trochantinal articulation and the cranial promotor of coxa. This muscle also serves to move the coxa forward and consequently the entire leg. It corresponds

with muscle 'pv6' of T.polyphemus and with muscle Nos. 38 and 48 of D.plexippus and P.demoleus respectively.

Sternal promotor of coxa (Figs.40 & 43; No.51).— It is a thick muscle composed of two bundles (a, b) arising separately on the median longitudinal ridge of basisternum. The two bundles take up oblique anteriorly directed course to end by a common base on the basicoxite anterior to the insertion of the cranial promotor of coxa. Like the cranial and pleural promotors, this muscle also serves to move the leg forwards. It can be compared with muscle 'st' of T.polyphemus and muscle No.48 of D.plexippus. Srivastava (1961) in P.demoleus also records a similar muscle (No.50).

Tergal remotor of coxa (Figs. 42 & 43; No.52).— A long thin muscle arising alongwith the second protractor of prospectus on the antero-lateral angle of the protergal stem, runs vertically downwards lateral to the pleural ridge, for insertion laterally on the proximal rim of the coxa posterior to the coxal articulation with the thorax. Due to the contraction of this muscle the fore-leg is brought back from the forward position. The muscle appears to act antagonistic to the cranial promotor of coxa. It can be compared with muscle No.37 of D.plexippus.

Pleural remotor of coxa (Figs.42 & 43; No.53).— A small fan shaped muscle which arises on the outer (lateral) side of the pleural ridge and running downwards gets inserted on the

basicoxite, posterior to the trochantinal articulation. Like the tergal remotor of coxa, the contraction of this muscle also pulls the coxa backwards and, consequently, the entire fore-leg is brou ht back to its normal position. It is similar to muscle (pva) of T. polyphemus.

First sternal remotor of coxa (Figs. 42& 43; No.54).— It is made up of two bundles arising separately as dorsal (a) and ventral (b) bundles on the sternal apophysis. These bundles, running obliquely downwards, end by a common base on the basicosta posterior to the pleural remotor of coxa. It can be compared with muscle 'st b' of T. polyphemus and with muscle No.41 of L. plexippus.

Second sternal remotor of coxa (Figs.42 &43; No.55).—This large bundle arises on the middle of the median longitudinal ridge of the furcasternum and is inserted on the ridge of the secondary groove of coxa. It can be compared with muscle (Stc) of T. polyphemus.

The contraction of the two sternal remotors pulls the entire leg backwards by making the coxa to work on the trochantinal articulation, thus, bringing the coxa back to its normal position.

First coxal levator of trochanter (Fig.44; No.56).— It is a thick muscle which arises on the basicosta as well as to some extent on the anterior wall of the coxa. The fibres descending vertically converge on a distinct dorsal apodeme which ends on the

middle of the concave dorsal half of the proximal rim of trochanter. This muscle can be compared with muscle 'Cx2a' of T. polyphemus. A similar muscle No.53 b' composed of two bundles, is recorded in P. demoleus.

Second coxal levator of trochanter (Figs.44 &45; No.57).— It is a short fan shaped muscle whose fibres arise on the posterior one-third of the lateral wall of coxa. Running vertically downwards the fibres converge on the dorsal apodeme of the trochanter. It may be compared with muscle 'Cx2b' of T. polyphemus and muscle No.54 of P. demoleus.

The above two levators work together in levating the trochanter. This, consequently, helps in lifting the rest of the leg.

Pleural depressor of trochanter (Figs.41 & 44; No.58).—It is a long muscle arising on the lower half of the episternum and the associated portion of the pleural ridge. The fibres passing through the coxal lumen are inserted on the ventral apodeme of the trochanter. It can be compared with muscle 'pvb' of T. polyphemus. Srivastava (1961) in P. demoleus regards a similar muscle as a bundle of his muscle No.55.

First coxal depressor of trochanter (Fig.44; No.59).— It is, more or less, equal to the first coxal levator of trochanter but arises in the upper half of the posterior wall of the coxa. This muscle runs vertically downwards for insertion on the

ventral apodeme. It may be compared with muscle 'Cx1' of T.polyphemus and the bundle 'b' of muscle No. 55 of P.demoleus.

Second coxal depressor of trochanter (Figs. 44 & 45; No. 60).— It is the smallest among the depressors of trochanter and originates on the lower one-fourth of the posterior wall of the coxa. It takes up a downward course to get inserted on the ventral half of the proximal rim of trochanter lateral to its connection with the ventral apodeme. This muscle is a special feature of Lepidoptera. It is comparable with muscle 'Cx3' of T.polyphemus.

The three depressors combiningly work on the ventral half of the proximal rim of trochanter which is made to bend upwards. This results in pulling down the distal end of the trochanter and consequently the rest of the leg is depressed.

Reductor of femur (Fig. 44; No. 61).— This small thick muscle, arising in the proximal half of the ventral wall of trochanter, converges to end on the posterior triangular apodeme of femur. The contraction of this muscle enables the femur to undergo slight movement of reduction. Ehrlich and Davidson (1961) show two such muscles in D.plexippus (Nos. 177 and 178). Similarly, Srivastava (1961) in P.demoleus records two muscles (Nos. 56 and 57). In U.pulchella, there is only one muscle as described above. This muscle is comparable with muscle No. 177 of D.plexippus and muscle No. 57 of P.demoleus, though these

differ slightly in their respective areas of origin. Further, Ehrlich and Davidson (1961) record the presence of muscle No. 177 only in the females of their insect, whereas, the reductor of femur is present in both sexes of U. pulchella.

Extensor of tibia (Fig. 45; No. 62).— It is a long pinnnate muscle whose fibres arise all along the dorsal wall of the femur and converge on a long narrow dorsal apodeme. The proximal end (base) of the apodeme flattens out into a triangular plate which is in conjunctival connection with the middle of the protruded dorsal half of the proximal rim of tibia. In case of females, the posterior series of fibres of the pinnate muscle is incomplete. This condition may be taken as a secondary sexual character for females. Ehrlich and Davidson (1961) in L. plexippus record single extensor of tibia in the females only. A similar muscle No. 58 is present in P. demoleus. The contraction of this muscle slightly bends downwards the dorsal half of the proximal rim of the tibia. Such change in the position of the proximal ~~tip~~ tip of the tibia makes the entire tibia to extend out.

Depressor of tibia (Fig. 44; No. 63).— A very thick pinnate muscle running ventral to the levator of tibia with fibres arising on the entire ventral wall of the femur. It is inserted on a long ventral apodeme whose base is shaped like a triangular plate. This muscle, functionally, is antagonistic

to the extensor of tibia. Its contraction exerts an upward pull on the ventral half of the proximal rim of tibia, which results in the depression of the entire tibia. This muscle is comparable with muscle No. 172 of P.plexippus and muscle No. 60 of P.demoleus.

Depressor of tarsus (Fig.45; No. 64).-- It is a small fan-shaped muscle arising in the distal half of the ventral wall of tibia. The muscle is inserted in the middle of the ventral half of the proximal rim of basitarsus. This muscle, on contraction, applies an upwards pull on the ventral half of the proximal rim of basitarsus, with the result that the latter is bent downwards. It is similar to muscle No. 176 of P.plexippus and muscle No. 62 of P.demoleus.

Flexor of claws (Fig. 45; No. 65).-- It consists of three bundles inserted on a very long tendon, which, starting from the femur passes through the entire length of tibia and tarsus, and ends on the proximal concave end of unguitractor. The first bundle (a) is spindle shaped which arises on the ventral half of the proximal rim of femur and is inserted on the proximal free end of the tendon. The tendon receives the second (b) and the third (c) bundles from the tibia. The bundle (b) arises from the proximal one-third of the dorsal wall of tibia, whereas, bundle (c) arises in the middle of the same wall. The contraction of the muscle affects the withdrawal of the unguitractor into the distal end of the last tarsomere, with the result that

a force is applied on the base of the claws, which are consequently flexed. In P. demoleus, the tendon of this muscle receives one bundle of fibres each from femur and tibia (muscle No. 63a, b).

(vii) Structure of the mesothorax (Figs. 27, 46, 47, 48, 49, 50, 51, 77 & 78).

The mesothorax is compact, strongly sclerotised and is the largest of the thoracic segments, occupying the major portion of the ptero-thorax. Its sclerites have developed various internal ridges which serve the dual purpose of providing it a bracing support against the pull of its muscles, as well as, giving origin to a number of muscles.

Mesotergum.-

The mesotergum is a large and dorsally convex sclerite which is clearly distinguishable into an anterior wing-bearing alinotum, and a postalar phragmanotum. The alinotum is further subdivisible into the prescutum, scutum and the scutellum.

Alinotum.-

Prescutum (Prsc).— The prescutum is the anteriormost submarginal narrow sclerite which is not visible in dorsal view because of its being bent downwards. It is demarcated from the scutum by an incomplete prescutal suture (ts). The latter, with a corresponding internal ridge (tR), is represented by two arms which start from the anterior margin and are directed towards each other. These, however, do not meet and,

thereby, fail to assume the typical form of prescutal suture. Anteriorly, the prescutum develops an emargination in the middle of its anterior margin (acP). Such concavity provides articulation to the base of the protergal stem (bTls). Further, the prescutum is merged with the narrow acrotergite, i.e., the first phragmanotum (PN1) along a clear antecostal suture (acs) which may be taken as the true inter-segmental line between the prothorax and the mesothorax. Since this acrotergite is separated from the base of the protergal stem by a narrow stretch of membrane, it is logical to consider this inter-segmental structure to have become a part of the meso-segment and, accordingly, it would be more appropriate to call it as the first phragmanotum. Madden (1944) in P. sexta shows the prescutum as a distinct sclerite. In P. americana, Snodgrass (1952) describes prescutum as short submarginal area with weak demarcating suture. However, a complete prescutum alongwith its normally developed inverted 'U' shaped prescutal suture is shown to occur in S. dasnaa (Alam, 1961).

The antecostal suture (acs) is internally represented by a broad flap like first phragma (1 Ph). The acrotergite (first phragmanotum) is also emarginated to contribute towards the completion of the articular concavity of prescutum, where the protergal stem articulates. Thus, the formation of the concavity is shared by the prescutum and the acrotergite. In other words, it is both segmental and inter-segmental in

origin. Kramer (1944) in A. oblongifolia and Müesch (1953) in T. polyphemus name the acrotergite as 'pretergite' and 'postnotum' respectively. Ehrlich (1958) in D. plexippus describes a bilobed phragma with paired 'phragmal arms'. No phragmal arms could be found in U. pulchella, nor such arms are reported in other Lepidoptera (Burgess, 1880; Madden, 1944 and Müesch, 1953). Srivastava (1962) in P. demoleus calls the first phragma as the 'antephragma'. He contends that since there are three phragmata in the thorax, they should be taken as 'antephragma', 'midphragma' and'postphragma'. Criticising Snodgrass (1935), Srivastava (1962) says that the latter calls the first and second phragmata as the pre- and post-phragmata respectively. He, further, considers that according to their positions,the second phragma should be the midphragma and the third phragma should be the postphragma. But, Snodgrass (1935) deals with only one ptero-thoracic segment and uses the term 'meso-postphragma' for the second phragma, which is quite logical. The second phragma is, undoubtedly, the postphragma of the mesothorax. The present writer upholds Snodgrass' view and is not prepared to accept Srivastava's(1962) interpretation. However, for brevity sake, the present writer prefers the terms first, second and third phragmata respectively, which will be dealt as such throughout this work.

Scutum (Sct).-- The scutum is distinctly convex and is the largest of the thoracic sclerites. It is bounded anteriorly by the obliterated prescutal suture and posteriorly by well

developed inverted 'V' shaped scuto-scutellar suture (vs). This suture is incomplete at the apex. Anyway it is internally represented by a distinct broad ridge (vR). The irregular lateral margin of the scutum is modified to provide articulations to the wings and their basal sclerites. An incomplete median longitudinal suture(mls) divides the scutum into two lateral halves. This suture starts slightly anterior to the apex of the scuto-scutellar suture and ends before reaching the prescutal suture. A similar suture has been shown by Madden (1944) in P. sexta, which he calls as 'median carina'. Likewise, Alam (1951) in S. dessae has confined the 'median suture' to the anterior portion of the scutum. The anterolateral angle of the scutum is produced into the ventrally directed prealar arm (Pra). The lateral margin just posterior to the prealar arm has developed an oblique fissure (of). Since the two fissures fail to meet, the scutum is saved from being subdivided. This condition is just the reverse of what is reported by Alam (1951) in S. dessae where the presence of a complete fissure has further subdivided the scutum into median and lateral scutal areas. Posterior to this fissure and extending upto the wing base the lateral margin of the scutum is concave(Con) and has been named as 'tegular incision' by Madden (1944)* in P. sexta. The

* Perhaps, he has used this terminology to signify the relationship of the tegula with this portion of the lateral margin. If it is so, then the term 'subtegular fossa' would be more appropriate for his insect. However, such demarcation is not acceptable to the present writer, specially when the so called 'tegular incision' does not provide articulation or direct association to the tegula.

remaining portion of the scutal lateral margin, providing necessary association to the wing and its sclerites, is highly irregular. However, two distinct processes can be detected. These, in respect to their direct articulations with the first and fourth axillary sclerites have been labelled as the anterior notal wing process (ANP) and the posterior notal wing process (PNP). Just following the anterior notal wing process is an incomplete oblique fissure (af) which helps the wing base conjunctiva to penetrate the scutum a little distance, and is here called as the axillary fissure. Such encroachment of the wing base on the scutum has resulted in the formation of a prominent sclerotic projection (PANP) in the lateral margin just posterior to the anterior notal wing process. This projection should not be confused with the anterior notal wing process, and is here termed as pseudo-anterior notal wing process. The true anterior notal wing process is short and stout with distinct anterior and posterior angles. It is the posterior angle of the anterior notal wing process which fits into a corresponding concavity borne by the mesal margin of the first axillary sclerite. The remaining portion of the mesal margin abuts against the anterior notal wing process between its anterior (N) and posterior (A) angles. Such association of the first axillary sclerite with the anterior notal wing process, consequently, drags the postero-mesal angle of the first axillary sclerite into the gate of the fissure and, thus, the posterior margin of the first axillary

sclerite automatically comes to rest on the pseudo-anterior notal wing process. Close to the base of the anterior notal wing process is a distinct secondary ridge (rM 1) which helps in locating the anterior notal wing process. Ehrlich (1958) in D. flavipnus calls it as 'scutal ridge'.

Madden (1944) in P. sexta shows two processes and calls them 'suralare' and 'adnotale' corresponding to the true anterior notal wing process and the pseudo-anterior notal wing process, respectively of U. pulchella. Madden (1944) is justified in his interpretation, since, he shows 'suralare' as the chief anterior pivotal point for the wing base and the 'adnotale' as an accessory articular point. Müesch (1953) in T. polyphemus labels the anterior projection as the 'anterior notal wing process' while the posterior projection as the 'median notal wing process'. Ehrlich (1958) in D. plexippus also finds two projections, the 'suralare' and the 'adnotale', and observes that the two projections articulate with the first axillary sclerite. This observation leads him to beleive that the two projections togather make up the 'anterior notal wing process'. In other words, according to him, the anterior notal wing process is a compound structure. The present writer is not prepared to accept the compound nature of the anterior notal wing process, and, further, feels convinced in considering only the anterior projection as the anterior notal wing process. It is this process which actually articulates with the first axillary sclerite, while the posterior process merely provides a

support to the same axillary sclerite. Madden (1944) in P. sexta and Ehrlich (1958) in D. plexippus call the fissure between the true anterior notal wing process and the pseudo-anterior notal wing process as the 'notal incision' and the 'scutal incision' respectively. Further, Nüesch (1953) in T. polyphemus labels it as 'tergal fissure'. The present writer considers it as a simple fissure and is not prepared to accept such type of terminology which may cause confusion. If at all, it is necessary to give a name to the fissure, it would be more appropriate to call it 'axillary fissure' (vide page 90).

In S. dessae, Alam (1951) shows that the anterior notal wing process is developed from the postero-lateral angle of the prescutum. Akbar (1957) in L. varicornis upholds this view. The present writer considers it to have been borne by the scutum. In other Lepidoptera, as well, the anterior notal wing process develops from the antero-lateral margin of the scutum (Madden, 1944; Nüesch, 1953; Ehrlich, 1958). This is quite logical, since, in these Lepidoptera, the prescutum is confined to the anterior margin of the alinotum.

The lateral margin of the scutum, close to its postero-lateral angle, is produced into a narrow, elongated posterior notal wing process (PNP), whose apex articulates with the base of the fourth axillary sclerite. Basally, the posterior notal wing process is demarcated from the scutum by a secondary ridge (rM2).

Madden (1944) in P.sexta shows two processes, an anterior process ('adnale') and a posterior process ('postadnale'). The 'adnale' is shown to serve as the posterior articulatory point for the wing and, hence, is comparable with the posterior notal wing process of U.pulchella. Ehrlich (1958) in D.plexippus has shown the presence of 'postalar plate' whose anterior process is called by him as the 'posterior notal wing process'. The term 'postalar plate' is not acceptable to the present writer, since, it is fundamentally a derivative of the postnotum, functioning as a sclerotic posterior limit of the wing base.

Scutellum (Scl).-- The scutellum is, more or less, rhomboidal in shape, and is demarcated from the scutum by the inverted 'V' shaped scuto-scutellar suture (vs). The two oblique arms of the suture run mesally directed but fail to meet by their apices. The incurved posterior margin is distinctly convex, and limited laterally by the axillary cords (Axc). The free posterior margin is in membranous connection (mb) with the second phragmanotum (PN2), but laterally bears a prominent socket (sc) for the articulation of the phragmanotum. The intervening membrane between the scutellum and the phragmanotum is extensive in the middle and narrows down laterally.

Phragmanotum (PN2).--

The phragmanotum is a narrow sclerotic band running along the incurved posterior margin of the scutellum and partially concealed by it. It is seperated from the latter by a narrow

stretch of membrane. Thus it is logical to consider this inter-segmental structure to have become a part of the meta-segment and accordingly, it would be more appropriate to call it as 'second phragmanotum' instead of meso-postnotum. Posteriorly, it is in sclerotic continuity with the meta-prescutum (Prsc3) along the antecostal suture (acs). The latter is a faint but complete concave suture internally represented by a very weak antecosta. The anterolateral angle of the phragmanotum is produced into a knob (PNark) to articulate with the corresponding socket in the lateral angle of the scutellum. The base of the articular knob extends obliquely over the phragmanotum and the second phragma. Ehrlich (1958) in L. plexippus shows the anterior angle of the phragma to articulate with the socket in the meso-scutum, and calls it the 'phragmal articulation'. The present writer is not prepared to accept it so long a complete phragma-notum precedes the phragma. Laterally the phragmanotum protrudes out as a flat plate whose continuity with the meso-epimeron makes it 'postalar bridge' (Pa). The distal margin of the bridge is distinctly concave. This condition of the margin has changed the distal end into an anterior (PaP1) and a posterior (PaP2) blunt process. It is actually the posterior process which is contiguous with the epimeron and from which arises the third indirect and secondary elevator of the fore-wing. The narrow anterior process is secondarily fused with the lateral margin of the scutum. Madden (1944) in P. sexta has failed to report the postalar bridge. The posterior process of the postalar bridge

can be compared with the 'laterophragma' of Papilio (Weber, 1933) and also with the 'phragma like process of the postalar bridge' of T. polyphemus (Nuesch, 1953). Ehrlich (1958) in D. plexippus reports a structure similar to the postalar bridge of U. pulchella and calls it the 'postalar portion of epimeron'. One may derive from Ehrlich's (1958) statement that the 'postalar bridge' is epimeral in origin. This fact is in contradiction to the conventional origin of the'postalar bridge' as maintained by Snodgrass (1935) and accepted by the present writer.

The antecosta is produced into a large, subtriangular second phragma (2Ph) with truncate apex, lying in the base of the first abdominal segment. This phragma, in association with the phragmanotum, forms an important area for the attachment of mesothoracic dorsal muscles. The phragma possesses an inverted 'U' shaped line (l) which is due to the difference in the intensity of sclerotisation of the phragma. Nüesch (1953) in T. polyphemus shows a similar line whose apices extend upto the apex of the phragma. He takes this line as the antecostal suture, and consequently, calls the area anterior and lateral to this line as the 'postnotum'. In U. pulchella, the present writer takes it as purely secondary.

Mesopleuron .—

The pleuron is represented by elongated episternum and 'U' shaped epimeron. These sclerotic plates are demarcated by an incomplete pleural suture (PlS), extending between the

coxal articulation (c) and the pleural wing process (PWP). The extensive dorsal margin is highly irregular commencing from the apex of the articular lobe of the tegular arm (TP) and ending with the line of fusion of the pleuron with the postalar bridge (Pa). This margin forms the lower limit of the wing base and possesses the pleural wing process (PWP). It has undergone a short marginal inflection which covers the point of merger of the pleural suture with the dorsal margin. The anterior margin, though irregular but short, starts from the anterior face of the apex of the articular lobe of the tegular arm and ends just anterior to the basalare (Ba). The mesal (ventral) margin, starting close to the basalare, continues upto the postero-mesal angle of the episternum. Since the posterior one-fourth of the mesal margin has a distinct internal ridge (spR) and fully satisfies the location of the sterno-pleural suture, it would not be unwise to take it as the sterno-pleural suture (sps). The posterior margin, commencing from the postero-mesal angle of the episternum, ascends to meet the dorsal margin along the line of fusion of the pleuron with the post-alar bridge. It forms the antero-lateral limit of the coxal socket and provides articulation to the coxa. It is evident that inspite of irregularity of limiting margins of the pleuron, these maintain sclerotic continuity with each other.

The pleural suture (Pls) is very distinct and takes up the normal course, dividing the pleuron into an anterior episternum (Eps) and a posterior epimeron (Epm). It starts from

the coxo-pleural articulation (c) and ascending in ventro-dorsal direction ends with the dorsal margin near the base of the pleural wing process. The pleural suture develops a strong internal ridge (PlR).

Dorsally, the well defined episternum is produced into the pleural wing process (PWP), which serves as a fulcrum for the fore-wing by providing articulation to the second axillary sclerite (2Ax). Kramer (1944) in A. oblongifolia, Alam (1951) in S. deesae, Akbar (1967) in L. varicornis, Ehrlich (1958) in D. plexippus and Srivastava (1962) in P. demoleus find the pleural wing process to develop from the pleuron. Madden (1944) in P. sexta shows that the pleural wing process is an extension of the antero-dorsal portion of the epimeron. The episternum is subdivided by a prominent transverse suture (Trs) into a dorsally placed anepisternum (AEps) and a ventral katepisternum (KEps), and contains a corresponding internal ridge (TrR). This suture may be called as trans-episternal suture connecting the mesal margin of the episternum with the pleural suture. Similar division of the episternum is shown by Madden (1944) in P. sexta, Alam (1951) in S. deesae and Srivastava (1962) in P. demoleus, where they call this transverse suture as 'anepisternal suture', 'secondary pleural suture' and 'episternal suture', respectively. Duncan (1939) in V. pennsylvanica calls a similar suture as 'transpleural suture' but does not name the subdivisions of the episternum. Wiesch (1953) in T. polyphemus, however, suggests no subdivision of the episternum. Ferris and Pennebaker (1939) and Matsuda (1956) in ~~Aedes aegypti~~ H. 2

Agulla adnixa H., donot base the subdivision of the episternum on sutural basis, but holding a cleft responsible for that purpose, call it the 'pleural cleft' separating the anepisternum from the katepisternum. Matsuda (1960) in Phasmus anerascens, however, prefers the term 'anapleural cleft' but finds it to separate the 'anepisternum' from the 'preepisternum'.

The anepisternum (AEps) is roughly divisible into an upper (dorsal) plate containing the pleural wing process and the tegular arm, and a lower (ventral) plate which carries the basalare on its anterior margin. The subdivision is due to unusual encroachment by the pleural membrane. No mention of such subdivision is made in Lepidoptera.

The tegular arm (TA) extends anteriorly from the base of the pleural wing process and is apically modified into a short, curved sclerotic plate, called the tegular plate (TP). The latter is directed upwards and is separated from the tegular arm by a line of flexion. The tegular plate articulates with the tegula (Tg) which is subtriangular in shape and covers the anterior three-fourths of the lateral margin of the scutum, the pleural wing process and the anterior portion of the tergo-pleural membrane (Madden's tegular incision). Its broad anterior end (Tga) lies slightly posterior to the prealar arm, while the tapering posterior end (Tge) extends upto the base of the fore-wing. There is a small orifice on the inner surface of the

anterior portion of the tegula which may be called as tegular orifice (Tgo) and which provides articulation to the tegular plate. The rim of the tegular orifice is in membranous communication with the tergo-pleural membrane. Madden (1944) in P. sexta calls the tegular arm as the 'sub-tegula'. Nüesch (1953) and Ehrlich (1958) show structures similar to U. pulchella in T. polyphemus and D. plexippus, respectively.

The katepisternum (KEps) is, more or less, rectangular in shape whose postero-mesal angle (ka) is attenuated. Anteriorly, the katepisternum is traversed by an incomplete transverse fissure (Trf), which runs parallel to the trans-episternal suture. This fissure appears to be secondary in nature. The katepisternum is mesally traversed by an oblique preepisternal suture (Pes), connecting the gate of the transverse fissure with the tip of the sterno-pleural suture. It is internally represented by a prominent ridge (PeR), and the mesal semi-circular portion of the katepisternum so cut off may be taken as the preepisternum (Peps). Shepard (1930) considers the preepisternal suture as a fairly consistent feature in Lepidoptera. Madden's (1944) observation of the preepisternal suture in P. sexta is rather complicated. This suture, as a matter of fact, is comparable with the preepisternal-cum-sterno-pleural suture of U. pulchella. Nüesch (1953) in T. polyphemus has shown a distinct 'prepectus', but has not

given the details on its demarcation. However, no prepectus is reported from Lepidoptera nor it is present in U. pulchella. Ehrlich (1958) in P. plexippus finds that the 'preepisternal ridge' arises from the 'precoxal ridge' to fuse dorsally with the 'pleural ridge'. Srivastava (1962) in P. demoleus shows the 'preepisternal suture' to continue ventrally with the 'presternal suture' forming a 'transverse suture'.

Postero-mesally, the katepisternum is traversed by a submarginal secondary groove (Ksg) with an internal ridge. The ridge is broadest at its junction with the pleural ridge. This groove starts before the posterior (ventral) limit of the pleural suture, and running mesally directed, ends before reaching the sternopleural suture. Shepard (1930) calls it the 'marginopleural suture' in Lepidoptera. Ehrlich (1958) also records the presence of the 'marginopleural suture' in P. plexippus. If at all, it is a suture, what are the sclerites separated by it? These authors make no mention of the separate sclerotic areas demarcated by the so called 'marginopleural suture'. This is the reason why the present writer considers it just a secondary groove.

The posterior portion of the pleuron forming the epimeron (Kpm) is, more or less, 'U' shaped. The area between the arms of the 'U' is run over by the axillary membrane (Amb). The epimeron is obliquely traversed by four short secondary

grooves; two of which are present in anterior arm, while the other two in the posterior arm of 'U'. The first groove (rM4) is comparable with the line which cuts off the so called 'preepimeron' from the epimeron as shown by Shepard (1930), Madden (1944) and Ehrlich (1958) in Lepidoptera, P. sexta and D. plexippus respectively. The same line is labelled as 'preepimeral suture' by Srivastava (1962) in P. demoleus. Shepard (1930) shows the 'preepimeron' in a number of Lepidoptera but does not name the suture separating it from the epimeron. Similarly, Madden (1944) in P. sexta and Ehrlich (1958) in D. plexippus report the presence of 'preepimeron' in their respective insects, but they too, donot assign any name to this suture. No 'preepimeron' is, however, shown in T. polyphemus (Nüesch, 1953). This obviously means that such subdivision of epimeron must have been based on strong morphological grounds. This is, however, lacking intthe papers where the subdivision has been reported. The present writer is not in favour of subdividing any morphological structure or region without sufficient morphological backing; and this is why, all the four lines are considered as mere secondary grooves. The so called 'preepimeron' is regarded as a mere marginal inflection comparable with an identical inflection of S. dessag (Alam, 1951). The second groove (rM5) is incomplete. It looks like an offshoot of the pleural suture. The third groove (rM6) starts from the postero-ventral angle of the posterior arm of epimeron and ends at the dorsal margin. The fourth groove (rM7), starting from the upper one-third of the

posterior margin of the posterior arm, ends at the dorsal margin. Ehrlich (1968) names the dorsal portion of the posterior arm as the 'postalar portion of epimeron'. This fact is not acceptable to the present writer and a discussion to this effect is given on page 96. The dorsal portion of the posterior arm (Epmd) of epimeron is provided with a small flap like projection (Y') for muscle attachment. The intersegmental membrane between the upper one-third of the posterior margin of epimeron and the meta-pleuron bears the second thoracic spiracle.

Mesosternum.—

The mesothoracic sternum is represented by a, more or less, triangular basisternum (Bs) and a small inverted 'V' shaped furcasternum (Fs). The two are demarcated by an unpaired apophyseal pit (ap). The base (anterior margin) of the basisternal triangle is drawn out in its middle to form a protrubrance (p). The arms of the spinasternum are associated with the anterior margin of the basisternum lateral to the median protrubrance. Each side (lateral margin) of the basisternum, in its basal one-third, is the sternopleural suture (sps), whereas, the remaining distal portion of the side is free and provides membraneus suspension to the coxa. The vertex of the triangle is, more or less, like an obtuse angle and represents the short posterior margin of the basisternum (v). The latter, instead of being horizontal to the body axis, has undergone upward curvature and bears the apophyseal pit at its bent end. The basisternum possesses the

midlongitudinal suture (mvs) extending from the anterior protrubrance to the foot of the vertex. The internal ridge (mvR) of the midlongitudinal suture attains its maximum elevation in its posterior portion. The unusual elevation of this ridge makes its posterior face to undergo secondary fusion with the anterior face of the vertex upto the apophyseal pit.

The inverted 'V' shaped furcasternum with its base at the apophyseal pit descends directed towards the coxae for articulation. The proximal portion of both the arms of the furcasternum is secondarily fused by its anterior face with the posterior face of the vertex of the basisternum; while the distal portion hangs free with no sclerotic association with the basisternum. The tip of the free distal portion of each arm of the furcasternum is modified into a small sternal articular knob (d) for articulation with the coxa.

Madden's (1944) description of the basisternum and furcasternum of P. sexta is sketchy and helps very little in understanding these subdivisions of the mesosternum and their interrelationships. He, however, shows the 'basisternum' with a 'midventral suture' and the 'furcasternum' separated by a 'median invagination'. Ehrlich (1958) in D. plexippus shows that the 'sterno-pleurites' unite midventrally along a'discrimen'. He does not show the apophyseal pit and the furcasternum. Matsuda (1960) in P. excrescens shows the presence of the basisternum and the furcasternum; the former being provided with a 'median longitudinal groove'. Srivastava (1962) in P. demoleus finds a small

triangular 'sternum' anteriorly limited by the 'presternal suture'. Since there is no presternum even in its incomplete form, the presence of 'presternal suture' does not seem to be valid. This portion may conveniently be taken as the remnant of the anterior margin of the sternum. He, further, suggests that the 'midventral line' (midlongitudinal suture of U. pulchella) is formed by the fusion of the two 'sternopleural sutures'. This obviously means that the pleuron has run over the conventional sternum to become greatly enlarged. This view that the 'midventral line' is a composite condition of the two 'sternopleural sutures' is not acceptable as a generalisation, since in U. pulchella, the sternopleural sutures and the midlongitudinal suture (midventral line') exist independantly. Still further, Srivastava (1962) says that the posteriorly drawn out portion of the pleura lying between the leg bases and ending at the 'furcal pit' should be taken as 'latero-sternite'. This, obviously, means his so called 'latero-sternites' can conveniently be taken as part of the conventional basisternum. It is surprising to find Srivastava (1962) rejecting the main subdivisions (basisternum and furcasternum) of the sternum which are of great fundamental significance in the insect morphology and at the same time highlighting the 'laterosternite' which is comparatively of least significance. Besides, he shows the 'meso-furcal pit' as 'external remnant of the meso-furcasternum'. It is thus apparent that he recognises the 'furcal pit' but at the same time does not give it the conventional status of separating the basisternum from the furcasternum. On the other hand, he makes it a part of

the furcasternum. How far his assessment of the'furcal pit' can be free from criticism is difficult to imagine. It is really very unfortunate that he has not gone through the work of Ferris (1960) which might have made him to give a second serious thought to his interpretations of the thorax of P.demoleus before putting it in black and white.

Endosternum.— The apophyseal pit (ap) invaginates to form the sternal apophysis (SA). The latter is 'Y' shaped with the stem of 'Y' soldered by its anterior face with the posterior portion of the midlongitudinal ridge beyond the apophyseal pit. The arms of the endosternum are the furcal arms (FA) which are like elongated bands. Each furcal arm is provided with a posteriorly directed flap like projection (Y) serving as attachment area for accessory extensor of the hind-wing. The furcal arm runs obliquely directed towards the epimeron and fuses with the dorsal portion of its posterior arm. This is undoubtedly a very unusual condition but the present writer is absolutely certain that the sternal apophysis does not have any association with the pleural apophysis. A similar condition has been reported by Madden (1944) in P.sexta, Nüesch (1953) in T.polyphemus and Srivastava (1962) in P.demoleus. On the other hand, Ehrlich (1958) in D.plexippus has taken them as 'secondary furcal arms' as he has been successful in recording the 'primary furcal arms' developing association with the 'pleural ridge'.

The coxal socket in U.pulchella is fairly large. Anterolaterally, it is bounded by the posterior margin of the pleuron;

whereas, its posterior and mesal limits are formed by the intersegmental membrane and the sternum (basisternum and furcasternum) respectively. The antero-lateral margin of the coxal socket (posterior margin of the pleuron) is produced into an articular knob at the base of the pleural ridge (c) and provides pleural articulation to the coxa. Similarly, the tip of the distal portion of the furcasternal arm serves as sternal articular knob (d) for articulation with the coxa.

Ferris' (1960) new concept is already described along with the prothorax (page 62). In view of this concept, the mesothorax of U.pulchella would be as follows: the 'dorsal plate' covers the entire mesonotum with its subdivisions; the 'limb-bases' engulf the pleura with their subdivisions, the basisternum and the furcasternum; the 'discriminal line' includes the midlongitudinal ridge, sternal apophysis and its pit.

(viii) Structure of the middle-legs (Figs. 46, 51, 52, 53, 54, & 59).

A detailed description of legs, their different parts, articulations and musculature has already been given in the case of the fore-legs. The author will, therefore, confine himself to the specialisations which have taken place in the ptero-thoracic legs.

The meso-coxa (Cx) is a considerably large, laterally compressed structure, tapering distally. The mesal side is sharply reduced giving way to the unusual enlargement of the proximal rim of the coxa (Cxpr). The latter is thickened all

along its course and bears a small concavity for pleural articulation almost in the middle of its lateral half (CxLArc). Just opposite to this and in the middle of the mesal half of the proximal rim is another concavity for sternal articulation (CxMArc). The anterior half of the proximal rim of the coxa is sharply inflected (miCxg) but externally there is practically no corresponding submarginal suture. Consequently, this is regarded as simple marginal inflection and not a part of basicosta. A similar condition is shown by Nüesch (1963) in T. polyphemus, where the marginal inflection is taken as 'basicosta'. Similarly, Ehrlich (1968) in D. plexippus calls this marginal inflection as 'eucoxal apodeme'. The coxa is traversed by an incomplete basicostal suture (bcs) extending from the pleural articular point to the distal rim of the coxa somewhere in between the two coxo-trochanteral articulations. It has a fairly strong corresponding internal ridge, called the basicosta (Bc). Thus, the coxa is divided into two longitudinal halves, the anterior among them becomes the 'coxa gemina' (Cxg) and the posterior one forms the 'meron' (Mer). The lateral portion of the proximal rim of meron is slightly inflected (miMer) to fall in line with the marginal inflection of the coxa gemina, and is closely apposed with the posterior margin of the pleuron (epimeron). This confirms that the ridge in question is a clear marginal inflection. The two coxo-trochanteral articulations (CxDArk) are borne by the coxa gemina. The meron and the coxa gemina fall in line with the epimeron and the episternum of the

mesopleuron respectively while the incomplete basicostal suture appears to be in line with the pleural suture. This condition of the coxa appears similar to a coxa divided by coxal suture falling in line with the pleural suture, but the two conditions being radically different, should not be confused. Madden (1941) in P. sexta shows a similar basicostal suture which divides the coxa into an anterior 'eucoxa' and a posterior 'meron'. He further shows that 'eucoxa' and the 'meron' are distally articulated with the trochanter. Such incomplete basicosta is labelled as 'merocosta' by Nuesch (1953) in T. polyphemus. Ehrlich (1958) in P. plexippus beleives in the division of the coxa into 'eucoxa' and 'meron' with the 'coxal suture' as their dividing line. Srivastava (1962) in P. demoleus finds a complete basicostal suture submarginal to the proximal rim of the coxa. He, further, shows the division of the coxa into 'coxal episternum' and the 'coxal epimeron' with the 'coxal suture' as their separating border. This unusual condition of both the basicostal suture and the coxal suture existing togather on a coxa is difficult to beleive.

The distal rim of the coxa (Cxdr) is not of normal oval or suboval shape. It is, however, distinctly thickened all along its course. Both the mesal and the lateral portions of the rim have undergone emargination (em). This, in other words, means that these portions of the rim have encroached over the respective coxal walls (mesal and lateral walls) and the

coxal areas encroached thereby are changed into spaces filled with conjunctiva. These emarginations, in combination, are named as trochanteral fossa, with the two halves as lateral and mesal fossae. Since the mesal portion of the proximal rim of coxa has also undergone extensive encroachment (emargination) over the mesal wall of the coxa, the two mesal portions of the proximal and distal rims have consequently come to lie close to each other with a narrow strip of sclerite intervening in between. This strip is actually the remnant of the mesal wall of the coxa with the mesal portion of the two rims forming its lateral and mesal limits. Nüesch (1953) in T. polyphemus and Srivastava (1962) in P. demoleus call this strip as 'sterno-coxale' because of the presence of the sternal articulation of the coxa with this strip.

The unusual emargination of the mesal and lateral portions of the distal rim of the coxa has reduced the anterior and posterior portions of the rim into small areas. The anterior portion of the thickened rim bears a conical knob (CxDArk). Likewise, the posterior portion of the rim bears another conical knob. But the difference is that the posterior portion has undergone wide thickening with the result that the corresponding portion of the posterior wall of the coxa is placed in a depression. The coxo-trochanteral articulation is exactly similar to that of the fore-leg.

The procedure for ascertaining the functions of the

muscles inserted on the proximal rim of the coxa, is the same as has been adopted for the fore-legs. If an imaginary axis is visualised to pass through the pleural and the sternal articulations, the coxa can be divided into two longitudinal halves, anterior and posterior halves. If the movements of the coxa are now watched , keeping this line of axis in mind, they are found to be forwards and backwards. The muscles influencing the movements of the legs are consequently inserted anterior and posterior to this line of movement and hence, they are taken as promotors and remotors.

The trochanter (Tr) of the mesothoracic leg is bigger than that of the prothoracic leg. The trochantero-femoral joint is exactly as seen in the fore-leg. The femur (Fm) of the mesothoracic leg is comparatively much longer and stouter than that of the prothoracic leg and tapers distally. The femoro-tibial joint is dicondylic like that of the fore-leg. The tibia (Tb) is very long, about double the length of the fore-tibia. It is proximally narrow and distally broad. The ventral wall of the tibia possesses a pair of small circular membranous areas close to its distal rim. To each of these membranous areas is attached the rounded base of a short tibial spur (Tbs) which tapers distally. The posterior spur is longer than the anterior one. Madden in P. sexta finds that the outer spur is twice the length of the inner one and is almost equal to one-half of the length of the tibia. The tibio-tarsal joint is mono-condylic as described

already in the fore-leg. The tarsus (Tar) is as long as the tibia and is exactly like that of the fore-leg. The pretarsus (Ptar) is in all respects similar to that of the fore-leg.

(ix) Musculature of the fore-wing.

Indirect and principal depressor of the fore-wing (Figs. 49 & 55; No. 66).— This is the largest muscle of the thorax. Running longitudinally it connects the second phragma of the thorax with the anterior region of the mesotergum. The muscle consists of five distinct bundles: the first two bundles (a,b) connect the apical half of the second phragma with the first phragma and the prescutum. The third bundle (c) puts the basal half of the second phragma in communication with the scutum. The last two bundles (d,e) are stretched between the second phragmanotum and the scutum. Since all these bundles have common area of origin and insertion, these cannot be regarded as separate muscles. Further, the fact that these bundles have common function and identical course of action, it would, all the more, be convincing to regard them as bundles of a single muscle rather than taking them as separate muscles.

The contraction of this muscle pulls the anterior and posterior regions of the mesotergum towards each other, resulting in its arching upwards and, thereby, depressing the wings. It can be homologised with muscle 'dlm1' of Pandila; muscle 'dlm-e'

of T.polyphemus and with the 'median dorsal muscle' of Lepidoptera (Maki, 1938). Srivastava (1962) in P.demoleus finds four separate muscles (Nos. 64, 65, 66 & 67) and assigns them the names according to their points of origin and insertion. He does not give any reason for taking them as separate muscles and deviating from the conventionally accepted plan of regarding these as bundles of a single muscle. Even outside Lepidoptera, in the standard works, these are considered as bundles of a single muscle, e.g., in V.pennsylvanica (Duncan, 1939), S.desseae (Alam, 1961) and honey bee (Snodgrass, 1956).

Indirect and principal elevator of the fore-wing (Fig. 55; No. 67).— It is a very broad tergo-sternal muscle consisting of two distinct bundles (a,b) which obliquely connect the scutum with the basisternum. In the basisternal region, the fibres are confined between the midlongitudinal ridge and the sternopleural suture. This may go a long way in confirming the sternopleural suture as the border between the sternum and the pleuron. The contraction of this muscle helps in flattening the arched tergum and, thereby, acts as antagonistic to the indirect and principal depressor muscle. It can be compared with the 'anterior tergosternal' muscle of Lepidoptera (Maki, 1938), muscle 'dv1a+b' of T.polyphemus. In P.plexippus, Ehrlich and Davidson (1961) show five separate muscles (Nos. 56, 57, 58, 62 and 63).

First indirect and secondary elevator of the fore-wing (Fig. 57; No. 68).— This tergo-pleural muscle of parallel fibres originates on the

free end of the prealar arm. Running dorso-ventrally, the fibres end on the outer surface of the basalare apodeme close to the anterior margin of anepisternum. It can be compared with the 'ordinary tergo-pleural muscle' of Lepidoptera (Maki, 1938), muscle 'pdl' of T. polyphemus, muscle No. 68 of D. plexippus and muscle No. 71 of P. demoleus. Alam (1951) in S. deesae shows a similar muscle running between the protergum and the 'basalare apodeme' of mesothorax. Due to the peculiar arrangement of the protergum in S. deesae, this muscle runs almost parallel to the corresponding 'principal extensor muscle' and Alam is justified in regarding it as a 'secondary extensor of the fore-wing'. On the other hand, in U. pulchella this muscle, though runs almost parallel to the second extensor of the fore-wing, acts antagonistic to it, and pulls the anterior region of the tergum downwards, helping its flattening. Hence, the present writer, on the basis of its action names it as the indirect and secondary elevator of the fore-wing. Further, the present writer calls it as secondary elevator for the simple reason that its own pull has no effect on the wing.

Second indirect and secondary elevator of the fore-wing (Fig. 57; No. 60)

This is also a tergo-pleural muscle, and arises on the anterior side of the mesonotum, lateral to the secondary ridge of the scutum (rM1). Running dorso-ventrally, the muscle ends on the outer surface of the basalare apodeme close to the mesal margin of anepisternum. The contraction of this muscle helps in flattening the anterior portion of the arched tergum and, thereby,

assists the indirect and principal elevator of the fore-wing. This muscle can be compared with the 'ordinary tergo-pleural muscle' of Lepidoptera (Maki, 1938), and muscle 'pd5' of T. polyphemus.

Third indirect and secondary elevator of the fore-wing (Fig. 56; No. 70).—

This muscle arises on the posterior process of the postalar bridge and ends on the posterior side of the scutum, lateral to the indirect and principal depressor. The contraction of this muscle helps in dearching the posterior region of the scutum and in conjunction with the indirect principal and secondary elevator., enables the whole of the scutum to elevate the fore-wing. This is primarily a dorso-longitudinal muscle but since it runs, more or less, dorso-ventrally, it assists the indirect and principal elevator muscle. It is a good example of a muscle anatomically belonging to one set of muscles while, functionally joining another set of muscles which is antagonistic to the first set. Nüesch (1963) in T. polyphemus has touched on the points of origin and insertion of this muscle (his muscle 'dl2'). It appears from his observation that this muscle should act on the postalar bridge though he does not say in so many words. If it is so, then it would be very difficult to believe that the movement of postalar bridge will assist in the elevation of the wing. It is unfortunate that Srivastava (1962) in P. demoleus has further toed the line of Nüesch (1963) without taking pains to judge the validity of his statement (see muscle No. 70 of P. demoleus).

First extensor of the fore-wing (Figs. 57 & 58; No. 71).— This is a thin muscle which originates on the preepisternum and running in ventro-dorsal direction gets inserted on the basalare apodeme close to the insertion of the first indirect and secondary elevator of the fore-wing. It can be compared with the 'sterno-basalare muscle' of Lepidotera (Maki, 1938), muscle 'pv1' of T. polyphemus, muscle No. 69 of P. plexippus and muscle No. 72 of P. demoleus.

Second extensor of the fore-wing (Fig. 57; No. 72).— This comparatively thick muscle arises on the marginal inflection of the proximal rim of coxa genuine. Running ventro-dorsally, its fibres are inserted on the inner surface of basalare apodeme. It can be taken as the 'coxo-basalare muscle' of Lepidoptera (Maki, 1938), muscle 'pv2' of T. polyphemus, muscle No. 70 of P. plexippus, muscle No. 80 of P. demoleus, the 'principal extensor muscle' of S. dessae and the 'extensor muscle' of the honey bee. In the latter two insects, the muscle is shown to arise on the 'meso-episternal plate' and the 'anterior part of the pleuron' respectively.

The contraction of the above two extensor muscles pulls down the basalare. This pull is transmitted to the wing, with the result that the latter extends out.

First flexor of the fore-wing (Figs. 57& 58; No. 73).— It is a thick muscle consisting of three distinct bundles inserted on the inner angle of the third axillary sclerite. One of the

bundles (a) arises on the dorsal margin of the anepisternum anterior to the pleural wing process; the other two bundles (b,c) arise partly on the thickened dorsal margin of epimeron close to the pleural wing process, and partly on the dorsal portion of the pleural ridge. The contraction of this muscle pulls the third axillary sclerite. This pull on the third axillary sclerite is responsible for the flexion of the fore-wing. This muscle is comparable with the 'pleuro-axillary'muscle of Lepidoptera (Maki, 1938), muscle 'pd2' of P.polyphemus. Ehrlich and Davidson (1961) in P.plexippus and Srivastava (1962) in P.demoleus, however, show two separate muscles each (muscle Nos. 78 & 82 of P.plexippus and muscle Nos. 74 & 75 of P.demoleus).

Second flexor of the fore-wing (Fig. 57; No. 74).— It is a long muscle arising distally on the lateral wall of meron. Running in ventro-dorsal direction, it ends on the inner surface of the subalare. The contraction of this muscle pulls the subalare down. This pull is transmitted to the second axillary sclerite through very short conjunctival bridge resulting in the flexion of the wing.

Originally, it is a leg muscle , but because of the close association of the subalare with the second axillary sclerite, it functionally becomes a muscle of the wing. Taking into consideration the association of the muscle with the coxal body, it appears convincing to regard it as a flexor muscle.

A similar muscle 'pv4' has been shown by Nüesch (1953) in T.polyphemus, but no definite function has been assigned to it. Srivastava (1962) in P.demoleus takes it as a leg muscle. However, Alam (1951) in S.dessae shows it to be the 'flexor of the fore-wing'.

Accessory flexor of the fore-wing (Fig. 57; No. 75).— It is a short muscle with , more or less, parallel fibres and originates on the flap like projection of the postero-dorsal portion of the epimeron. The fibres, running obliquely in ventro-dorsal direction , get inserted on the posterior portion of the subalare. The action of this muscle is transmitted to the ventral angle of the second axillary sclerite through very short conjunctival bridge, thus helping the flexors of the fore-wing. This muscle is a common feature of Lepidoptera but no function has been assigned to it. The present writer declares it as a flexor of the fore-wing.

Depressor of Tegula (Fig. 58; No. 76).— It is a short fan shaped muscle which arises by a narrow base on the tegular arm close to the pleural wing process. Ascending obliquely, the muscle gets inserted on the apical portion of the tegular plate. On contraction, it pulls the tegular plate downwards which, in turn depresses the tegula. It is similar to muscle 'pd4' of T.polyphemus, muscle No. 67 of P.plexippus and muscle No. 77 of P.demoleus. In the former insect, however, it is shown to arise on the prescutum.

Mesothoracic furco-pleural muscle (Fig. 57; No. 77).— It is

also a fan shaped muscle arising on the middle of the pleural ridge and on the adjascent dorsal margin of epimeron. The fibres running antero-posteriorly converge to form a long tendon which is inserted on the anterior surface of the furcal arm. The muscle passes mesal to the second flexor of the fore-wing. This muscle protects the meso-endosternum from undergoing any distortion due to the working of the third and fourth remotors of coxa. Similar function has been attributed to such muscle in the wasp and S. deasae by Duncan (1939) and Alam (1951) respectively. It is also comparable with the 'furco-entopleural muscle' of Lepidoptera (Maki, 1938), muscle 'pv7' of T. polyphemus and muscle No. 73 of P. demoleus.

Intersternal muscle between meso- and metasterna (Fig. 69; No. 78).—

This muscle is made up of two bundles which run between the posterior surface of the meso-furcal arm and the antero-lateral surface of the lateral process of meta-endosternal neural plate. The contraction of the muscle resists the displacement of the endosterna of meso- and metathorax, which are likely to undergo displacement due to the action of thoracic muscles arising on them. It can be compared with the 'longitudinal ventral muscle' of Lepidoptera (Maki, 1938), muscle 'vll' of T. polyphemus and muscle Nos. 85 and 97 of D. plexippus and P. demoleus, respectively.

(x) Musculature of the middle-legs.

Since the middle coxa articulates with the pleuron,

as well as, with the sternum, its movements are comparatively more defined and are controlled by the following muscles.

First promotor of coxa (Fig. 56; No. 79).— This thick muscle arises on the middle of the lateral margin of scutum, lateral to the origin of the indirect and principal elevator of the fore-wing. The fibres, running in dorso-ventral direction, converge to end on the anterior marginal inflection of the proximal rim of coxa. It can be taken as the 'tergal promotor of coxa' of Lepidoptera (Maki, 1938), muscle 'dv2' of T. polyphemus, muscle No. 63 of D. plexippus and muscle No. 79 of P. demoleus.

Second promotor of coxa (Fig. 58; No. 80).— A flat fan shaped muscle which arises dorsally on the anterior surface of the pleural ridge. The fibres converge to form a tendon which is inserted on the proximal rim of the coxa lateral to the first promotor of coxa. This muscle is called the 'pleural abductor of coxa' by Maki (1938). A similar muscle is called the 'lateral promotor of coxa' in S. depsaea by Alam (1951). This muscle is comparable with muscle 'pv6' of T. polyphemus and muscle No. 83 of D. plexippus.

Third promotor of coxa (Fig. 59; No. 81).— This fan shaped muscle is much smaller than the second promotor of coxa. The fibres, arising posteriorly on the midlongitudinal ridge of basisternum, descend obliquely in a convergent

manner to get inserted on the anterior half of the proximal rim of coxa mesal to the insertion of the first promotor of coxa. It may be taken as the 'ordinary sternal promotor of coxa' of Lepidoptera (Maki, 1938), muscle 'st1' of T. polyphemus, and muscle Nos. 55 and 78 of D. plexippus and P. demoleus respectively. Alam (1951) in S. dessae calls a similar muscle as the 'mesal promotor of middle coxa'.

On contraction, the above three muscles promote the coxa and, consequently, the entire leg is moved forward.

First remotor of coxa (Figs. 55 & 56; No. 82).— It is a large muscle with, more or less, parallel fibres arising laterally on the middle of the scutum. Running dorso-ventrally, the fibres converge to end on the posterior half of the proximal rim of coxa. This muscle is similar to the 'tergal remotor of coxa' of Lepidoptera (Maki, 1938) and muscle 'dv5' of T. polyphemus.

Second remotor of coxa (Figs. 56, 57 & 58; No. 83).— This muscle is similar to the first remotor of coxa and arises anterior to the first remotor. The fibres take up a dorso-ventral course to end on the posterior half of the distal rim of coxa. It is comparable with the 'tergal remotor of coxa' of Lepidoptera (Maki, 1938) and muscle 'dv4' of T. polyphemus.

Third remotor of coxa (Fig. 59; No. 84).— The parallel fibres of this thin flat muscle arise posteriorly on the furcasternum to get inserted on the posterior half of the

proximal rim of coxa lateral to the first remotor. This muscle is comparable with the 'ordinary sternal remotor of coxa' of Lepidoptera (Maki, 1938), muscle 'st3' of T.polyphemus and muscle No. 75 of D.plexippus.

Fourth remotor of coxa (Figs. 59 & 60; No. 85).— It is a thin muscle with, more or less, parallel fibres arising laterally on the sternal apophysis. The fibres running obliquely are inserted on the distal half of basicosta. Since the basicosta is posterior to the axis of movement of the coxa, it is suggested that the extrinsic muscles ending on it should work in association with the remotors of coxa which are inserted on the posterior half of the proximal rim of coxa. This muscle corresponds with the 'sternal remotor of coxa' of Lepidoptera (Maki, 1938), muscle 'st4' of T.polyphemus and muscle No. 66 of D.plexippus.

The above four remotor muscles act antagonistic to the promotor muscles and thus, on contraction, the coxa is swung backwards. Consequently, the entire leg is pulled back from its advanced position.

First levator of trochanter (Figs. 60, 61 & 62; No. 86).— A very thick muscle whose fibres arise on the undersurface of the marginal inflection of coxa genuina, as well as, on the anterior face of the proximal three-fourths of basicosta. The fibres converge to form a short tendon which is inserted on the dorsal apodeme of trochanter. It can be taken as muscle

'ex2' of T.polyphemus and muscle No. 74 of D.plexippus.

Second levator of trochanter (Figs. 59, 61 & 62; No. 87).— This muscle is very short as compared to the first levator. It arises posteriorly on the mesal half of the distal rim of coxa (meron). The fibres converge to get inserted on the dorsal half of the proximal rim of trochanter just posterior to the dorsal apodeme. This muscle can be homologised with muscle 'ex3' of T.polyphemus and muscle No. 76 of D.plexippus.

The above two levator muscles work togather in levating the trochanter and, consequently, the entire leg is lifted up.

First depressor of trochanter (Figs. 56 & 62; No. 88).— This muscle is composed of three thick bundles (a,b,c) which arise side by side on the scutum lateral to the origin of the first promotor of coxa but mesal to the origin of the second remotor of coxa. The three bundles, running dorso-ventrally, are inserted, by a common base, dorsally at the distal end of the ventral apodeme of trochanter. It can be compared with the 'tergal depressor of trochanter' of Lepidoptera (Maki, 1938), muscle 'dv3a+b' of T.polyphemus and muscle Nos. 59+64 of D.plexippus.

Second depressor of trochanter (Figs. 57 & 62; No. 89).— It is a long thin muscle which arises on the undersurface of the basalare apodeme posterior to the insertion of the second

extensor of the fore-wing. Running obliquely downwards, the muscle is inserted dorsally on the ventral apodeme of trochanter proximal to the insertion of the first depressor of trochanter. It is similar to the 'trochantero-basalar' muscle of Lepidoptera (Maki, 1938), muscle 'pv3' of T. polyphemus and muscle No. 71 of D. plexippus.

Third depressor of trochanter (Figs. 59, 60, & 61; No. 90).— This muscle is made up of parallel fibres and originates on the anterior face of the sternal apophysis. Running ventrally, the fibres end on the distal end of the ventral apodeme of trochanter mesal to the insertion of the second depressor of trochanter. The muscle can be compared with the 'sternal depressor of trochanter' of Lepidoptera (Maki, 1938), muscle 'st2' of T. polyphemus and muscle No. 77 of D. plexippus.

Fourth depressor of trochanter (Figs. 60, 61 & 62; No. 91).— It is also made up of parallel fibres arising on the marginal inflection of coxa gemina. The fibres running obliquely in an antero-posterior direction find their insertion on the anterior face of the proximal half of the ventral apodeme of trochanter. It can be taken as muscle 'cx1' of T. polyphemus and muscle No. 72 of D. plexippus.

Fifth depressor of trochanter (Figs. 59 & 62; No. 92).— It is a short fan shaped muscle arising on the mesal half of the distal rim of meron to get inserted proximally on the

mesal face of the ventral apodeme of trochanter.

The above five depressor muscles combiningly work on the ventral half of the proximal rim of trochanter which is made to bend upwards. This results in pulling down the distal end of the trochanter and consequently the rest of the leg is depressed.

(xi) Structure of the metathorax (Figs. 27, 49, 63, 64, 65, 66, 67 & 84).

The metathorax is smaller than the mesothorax but is equally sclerotised.

Metatergum.--

The metatergum is anteriorly fused with the second phragmanotum. Its posterior margin is also fused with the first abdominal tergum. A narrow membrane exists between the metaprescutum and the meta-scutum, as well as, between the scutellum and the third phragmanotum. Such membranous interventions provide intra-segmental flexure to the metathorax. Laterally, the metanotum is in membranous continuity with the pleura except in its posterior portion where the third phragmanotum is in sclerotic contiguity with the metepimera. Since the hind-wings are also functional, the tergal subdivisions are broadly in conformity with the subdivisions of the mesotergum. The metanotum can conveniently be divided into an anterior alinotum and a posterior phragmanotum. The alinotum is again divisible into prescutum, scutum

and scutellum.

Alinotum.-

Prescutum (Prsc).- The prescutum is present in the form of a narrow submarginal sclerotic band which is, normally, not visible on account of its inflected nature. The antecostal suture(acs2), with well developed antecosta (second phragma), puts the second thoracic acrotergite (second phragmanotum) in sclerotic contiguity with the prescutum. The posterior margin of the prescutum is emarginated in the middle to allow the median portion of the scutum to fit in. The prescutal suture (ts) separating the prescutum from the scutum is much obliterated and replaced by conjunctiva. It is distinctly of sutural nature in antero-lateral regions of the tergum being internally represented by a distinct ridge (tR)where it keeps the small lateral lobes of the prescutum, i.e., the prealar arms (Pra) in sclerotic contiguity with the scutum. The remaining major portion of the suture is secondarily replaced by a closed fissure (tf). This intervening membrane renders the prescutum flexibly movable over the scutum. Such movement is due to the action of the wing muscles on the second phragma. The present writer regards the replacement of a major portion of the prescutal suture by a fissure as a modification to allow complete and unhindered working of the second phragma under its muscular action. This would, otherwise, in the absence of this fissure, might have been retarded by the brake applied

on it by the metascutum. Madden (1944) in P. sexta, Ehrlich (1958) in D. plexippus and Srivastava (1962) in P. demoleus do not report the presence of the prescutum. Treat (1959) in Crymodes devastator B., separates the prescutum from the scutum in almost similar manner as recorded in U. pulchella. The prescutum is laterally produced into a posteriorly directed well sclerotised small prealar arm (Pra). The two prealar arms are connected with one another by the long narrow band like median portion of the prescutum. Madden (1944) in P. sexta, Nüesch (1953) in T. polyphemus, Ehrlich (1958) in D. plexippus and Srivastava (1962) in P. demoleus fail to record the prealar arm. Thus, it can be inferred that the presence of distinct prealar arms is, for the first time, reported in Lepidoptera.

Scutum.— The metascutum is anteriorly bounded by the prescutal suture including its portion forming the fissure. Posteriorly, it is demarcated by the well developed convex scuto-scutellar suture (vs) with a strong internal ridge (vR). The irregular lateral margin of the scutum is modified to provide articulation to the hind-wings. The metascutum consists of two large lateral portions (lSct) and a small median portion (mSct). The latter is, more or less, triangular whose broad apex bends downwards to enter into the corresponding emargination present in the posterior margin of prescutum. The lateral portion (lSct) is roughly rectangular with broad lateral margin. The posterior half of the lateral margin

bears two distinct projections which may be taken as anterior (ANP) and posterior (PNP) notal processes on account of their direct articulation with the first axillary sclerite and the third axillary sclerite respectively. The anterior half of the lateral margin develops two small oblique fissures (of1 & of2) which enclose a blunt projection of the margin. This is named as the pseudo-anterior notal wing process (PANP). The first axillary sclerite rests on it. A similar projection is shown to occur posterior to the anterior notal wing process in the mesothorax (page 90). The anterior notal wing process (ANP) is pointed and provides direct articulation to the postero-mesal angle of the first axillary sclerite. Unlike the mesothorax, no angle of the first axillary sclerite enters into the fissure. Madden (1944) in P. sexta calls the anterior notal wing process as 'suralare', and has shown it to articulate with the first axillary sclerite. Ehrlich (1958) in P. plexippus retains the term 'anterior notal wing process'. Srivastava (1962) in P. demoleus records a reduced 'anterior notal process'.

An oblique groove (r1) extends from the tip of the anterior notal wing process and runs submarginal to the posterior margin of the scutum to end near the scutellum. This groove is internally represented by a distinct broad ridge (rp). The latter freely projects as a flap into the body cavity. The ridge is called 'Spannliesto' by Eggers (1919) and 'scutal phragma' by Richards (1933) in the Noctuoidea. Treat (1959) in C. devastator retains the terminology suggested by Richards.

These authors take it as a modification of the scutum to serve as dorsal brace for the tympanic air sac. The groove marks off a posterior narrow and less sclerotised plate (n) from the scutum which bears the two notal wing processes. Laterally, this plate is produced into a long narrow projection to articulate with the third axillary sclerite. The present writer takes it as the posterior notal wing process (PNP). Madden (1944) in P. sexta calls it the 'adanale' and Ehrlich (1958) in D. plexippus takes it as 'posterior notal wing process'. Alam (1951) in S. dasenas names the part of the scutum bearing posterior notal wing process as the 'metanotal ramus'.

Scutellum (Scl).— The oblong shaped scutellum lies posterior to the scuto-scutellar suture (vs). The latter is well developed with distinct internal ridge (vR). It runs transversely making a semi-circle. Nüesch (1953) in T. polymnestus shows a 'V' shaped ridge. The lateral ends of the scutellum receive the axillary cords (Axc). Richards (1933) in the Noctuoidea and Treat (1959) in C. devastator show the presence of 'alula' in the form of an extension of the anterior angle of the scutellum. No such modification is traceable in U. pulchella. The posterior margin of the scutellum is inflected. It is separated from the third phragmanotum (PN3) by a very narrow stretch of membrane (mb) which is distinctly inter-segmental in origin.

Phragmanotum (PN3).-

The third inter-tergal plate (acrotergite) forms the third phragmanotum. Since this acrotergite is separated from the metascutellum by a narrow intervening membrane, it is logical to consider this inter-segmental structure as well to have become a part of the following segment, i.e., the first abdominal tergum and accordingly it will be more appropriate to call it as the third phragmanotum instead of the metapostnotum. The third phragmanotum has undergone peculiar structural modification, so far, not recorded in insects. This peculiarity may be attributed to the presence of the tympanal organs in the metathorax. The phragmanotum consists of three plates, which being contiguous with each other give it the shape of a 'Y'. The short stem (as) of 'Y' is ventral in respect to the short anterior (ob) and long posterior (om) arms. The anterior arm (ob) is suspended from the posterior margin of the metascutellum by a narrow membrane (mb). This arm in continuation with the stem gives the impression of the inflected posterior margin of the scutellum. The posterior arm starting from the point of bifurcation (o) ascends obliquely to meet the anterior margin of the first abdominal tergum along the antecostal suture (m). The base of the stem (a) undergoes a secondary extension in the form of a posteriorly directed plate (ag) which is about twice the combined lengths of the stem and the posterior arm (as+om). The course of this secondary plate (ag) is almost parallel to the body axis. Somewhere in the middle of the plate, its

dorsal surface is fused with the oblique/ly running third thoracic phragma (3Ph). The present writer regards this fusion as purely secondary which imparts rigidity to this secondary plate (ag). Alam (1951) in S.dasnae has also shown the third phragma to to have/become the part of the propodeal tergum which is naturally the the first tergum of the abdomen. The seconadary plate (ag) all along its lateral margin is contiguous with the metaepimeron. The anterior angles of the secondary plate (ag) are modified into oval membranous fossae (PNf) comparable with the 'countertympanic membrane' of the Lepidoptera(Richards, 1933) and C.devastator (Treat,1959). The posterior arm is demarcated from the first abdominal tergum (1T) by a distinct antecostal suture (m) which internally bears the well pronounced third phragma. The indirect and principle depressor muscle of the hind wing stretches between the antarior face of the stem-cum-anterior arm of the phragma (aO+ob) and the scutum of the metanotum. Similarly, the dorsal longitudinal muscle of the first abdominal tergum does not go beyond (anterior) the antedostal suture (m). These two muscles of fundamental singificance in insect morphology support the interpretation given by the present writer, of the third phragma-notum.It can now be safely/be inferred that all the three phragma-nota have secondarily moved backwards to develop sclerotic continuity with the following terga. Likewise, anteriorly, these maintain membranous connections with the preceding terga.

Nüesch (1953) in T.polyphemus does not show any conjectural intervention between the posterior margin of the meta-

scutellum and the anterior margin of the postnotum. This obviously means that sclerotic continuity between the scutellum and the postnotum (phragmanotum of U. pulchella) exists. He also shows sclerotic continuity of the postnotum with the first abdominal tergum which appears to break along a line. He does not identify this line, which, probably, is the antecostal suture because of its relationship with the third phragma (Nüesch, 1953; Fig. 1). It can, thus, be concluded that Nüesch (1953) has posed a condition in which the intersegmental acrotergite has broken the conventionally accepted principle by virtue of which the acrotergite should join either the preceding plate or the following plate. This interpretation of Nüesch (1953) would have been a novel addition to the morphology of insect thorax; but the fact that in U. pulchella the acrotergite (phragmanotum) is distinctly separated from the scutellum by very narrow but complete streak of conjunctive, makes it very difficult for the present writer to accept it. The contentions of the present writer that the third phragmanotum is separated from the metascutellum by an intervening conjunctival membrane and that the third phragmanotum is posteriorly in contiguity with the first abdominal tergum through the antecostal suture, get some strength from the observation of Ehrlich (1958) in D. plexippus. The statement of Ehrlich (1958) about the metapostnotum, broadly speaking, is close to the contentions of the present writer. Nevertheless, from the diagram, as well as, the description of metapostnotum given by Ehrlich (1958)

some confusion arises which could have been cleared if Ehrlich had decided to give a little more detailed account of this plate. The present writer thinks that the ventral portion of the meta-postnotum in *D. plexippus*, though not labelled or described in detail by Ehrlich (1958), probably, is comparable with the secondary plate (ag) of the phragmanotum of *U. pulchella*. It is, thus, clear that the contention of the present writer about the third phragmanotum and its details has been for the first time, recorded in Lepidoptera. It can further be said, that such interpretation of the meta-postnotum, leaving aside Lepidoptera, has not so far been given in any other group of Insects. It is quite likely that this interpretation may amount to an addition to the morphology of insect thorax. The interpretation of postnotum as given by Srivastava (1962) in *P. demoleus* is not very convencing. It may be attributed to, besides other points, his inability to find an intervening conjunctiva between the scutellum and the postnotum.

Metapleuron.—

The metapleuron, like the mesopleuron, consists of elongated episternum (Eps) and 'V' shaped epimeron (Epm), separated by a well defined pleural suture (Pls) ascending from the pleural coxal articulation (c) to the base of the pleural wing process (PlP). The dorsal margin of the pleuron is extensive, as well as, highly irregular. It begins close to the base of the basalare (Ba) to end at the point of fusion of the epimeron with the secondary extension of the phragmanotum. Almost

in its middle, the dorsal margin extends close to the subalare because of the dorsal protrusion of the epimeron. The dorsal margin forms the lower limit of the wing base and possesses the pleural wing process. Like the mesothorax, the anterior margin of the pleuron is short, and, starting near the base of the basalare, ends at the anteromesal angle of the epist-ernum. At the junction of the dorsal and anterior margins, there is a distinct concavity (Bac) which provides articulation to the base of the basalare. The mesal (ventral) margin extends between the antero-mesal and the postero-mesal angles of the episternum. The dorsal one-third of the mesal margin is incurved (im), whereas, its ventral two-thirds have a distinct ridge (spR). The latter demarcates the episternum from the basisternum. Hence it would not be unjustified to call it as the 'sterno-pleural' suture (sps). The posterior margin commencing from the postero-mesal angle of the episternum (ka), ascends to meet the dorsal margin, round the phragmanotal fossa. The posterior margin forms the antero-lateral limit of the coxal socket, and provides articulation to the coxa. It is, thus, clear that inspite of the irregularity of the pleural margins, these maintain sclerotic continuity with each other, a condition similar to that of the mesothorax.

The pleural suture (Pls) is fairly distinct and ascending from the coxo-pleural articulation ends at the base of the pleural wing process. The pleural suture, on its way to the pleural wing process, becomes confluent, for a short

distance , with the dorsal margin. The pleural ridge (PlR) is distinct throughout. The pleural suture divides the pleuron into an anterior episternum and a posterior epimeron.

Dorsally, the epimeron (Epm) is produced to form the wing fulcrum, commonly known as pleural wing process (PWP). The latter provides articulation to the second axillary sclerite (2 Ax). Ehrlich (1958) in D.plexippus and Srivastava (1962) in P.demoleus consider that both episternum and epimeron contribute to the formation of the pleural wing process. The present writer that suggests that such difference in the formation of pleural wing process may be due to the course, as well as, the ending of the pleural suture.

The episternum is roughly rectangular. It is entire and not divided into anepisternum and katepisternum. This condition is just the opposite to one present in the mesothorax, where, the anepisternum and katepisternum are distinct entities. Similar undivided condition is reported in the meta-episternum of P.sexta and T.polyphemus (Madden, 1944; Nüesch, 1953) respectively. Ehrlich (1958) in D.plexippus, however, finds a small, well defined, sclerotic anepisternum separated from the basalare and the pleural wing process by a distinct line suture. Srivastava (1962) in P.demoleus has recorded the presence of a large anepisternum and a small katepisternum separated from each other by the 'episternal suture'. The postero-mesal angle of the episternum (ka) is attenuated. Unlike the mesothorax, here, the pre-episternal suture and pre-episternum are wanting. Similar stand is

taken up by Madden (1964) in P. sexta who shows the episternum confluent ventrally with the basisternum. Such confluence would have been visualised in U. pilichella also if the sternopleural suture had been absent. Nüesch (1953) in T. polyphemus shows the 'pre-episternum' separated from the episternum by a ridge called 'episternal ridge'. An 'insignificant pre-episternum' which does not continue ventrally to the level of the coxa, is reported by Ehrlich (1958) in D. plexippus. Srivastava (1962) in P. demoleus also records the 'pre-episternum' separated from the episternum by the 'pre-episternal suture' and holds the formation of the 'prepectus' by the fusion of the 'pre-episterna'.

Posteriorly, the episternum is traversed by a secondary submarginal groove (r2), with a distinct internal ridge, originating from the pleural suture near its ventral end. After traversing a short distance, it ends before reaching the sternopleural suture. The lepidopterists call it the 'marginopleural suture', e.g., Ehrlich (1958) in D. plexippus. The present writer has already dealt with it earlier (page 100).

The broad portion of the pleuron, posterior to the pleural suture, is the epimeron. It is, more or less, 'U' shaped . The area between the two arms is filled with axillary membrane containing the subalare. The anterior arm (aE) is almost straight while the posterior one (pE) is sickle shaped. It is this arm which makes the epimeron solely

responsible for the formation of the tympanal frame. The latter develops four auditory pockets (PI-PIV) as a result of appearance of secondary grooves on it.
These can be grouped into two pairs, viz., dorsal and ventral pairs. One of the pockets in each group is anterior (PI and PIV) in respect to the other which is posterior (PII and PIII). The anteriors are directed forward while the posteriors face backwards. Richards (1933) in the Noctuoidea and Treat (1969) in C. devastator put the tympanal frame under dual resposibility of the epimeron and the postnotum. They also record four pockets with the only difference that they have assigned the posterior pockets of the two groups to the postnotum. Since in U. pulchella, the phragmanotum does not descend uptothe level of the posterior pockets (pockets II and III of C. devastator), it is considered advisable to assign them to the epimeron. The free dorsal tip of the posterior arm of epimeron provides a shallow concavity for the articulation of the stalk of subalare (SaSt). The ventral margin of the anterior dorsal pocket is slightly extended, not actually produced, which, Eggers (1919) in the Lepidoptera calls as 'Bugel', and shows that the tympanal nerve is attached to it. Richards (1933) in the Noctuoidea, however, finds this structure to be present only in Catocala, whereas, Treat (1969) finds it as a fairly prominent structure in C. devastator and remarks that no species studied by him lacks it completely. The epimeron, almost in its middle, is produced upwards as an elongated sclerite (NScl) ending just before the free end of the posterior

arm. This sclerite is rightly named as 'nodular sclerite' by Richards (1933) in Noctuoidea. It divides the wing base membrane into anterior and posterior portions. The present writer calls these subdivisions as articular membrane of the wing (Wm) and the tympanic membrane (Tm) respectively. The same subdivisions have been labelled as the 'false tympanic membrane' and the 'tympanic membrane' respectively by Richards (1933) in the Noctuoidea and Treat (1959) in C. devastator. The nodular sclerite is traversed by a secondary groove (r3) extending dorsally from the coxo-pleural articulation. Near the base of the nodular sclerite the secondary groove gives out an anteriorly directed short groove (r4) which merges with the dorsal margin of the epimeron. The present writer considers these two grooves as purely secondary without any morphological significance.

The ventral surface of the posterior arm fuses with the furcal arm of its side. The entire posterior margin of the epimeron receives the membranous sterno-pleural region of the first abdominal segment. It is also partly fused with the bar like sclerotic portion of the first abdominal sternum (1s). The posterior half of the epimeron is concealed under the 'hood' (h) of the tympanum which is formed by the modification of the membranous first abdominal pleuron.

Metasternum.-

The metasternum is represented by a, more or less, 'V' shaped basisternum (Bs) and an elongated furcasternum (Fs).

The two are demarcated by an unpaired apophyseal pit (ap). The anterior margin of the basisternum, in its middle, forms a protrubrance (p) while its lateral margin is confluent with the sternopleural suture. The short posterior margin (v), forming the base of the 'V' shaped basisternum, is almost like an obtuse angle and undergoes an upward curvature with the apophyseal pit located at its bent end. This splits the basisternum into a horizontal and avertical portion. The mid-longitudinal suture (mvs) of the basisternum extends from the anterior protrubrance to the apophyseal pit. The internal ridge of this suture is all along very thick excepting the point of upward bending of the basisternal posterior margin where it is very thin. In view of the shape of the the basi-sternum, the midlongitudinal suture and its ridge may be split up into a horizontal and vertical portions(mvR1 and mvR2), running on the respective horizontal and vertical portions of the basisternum. These are contiguous through the thin portion of the ridge.

The elongated furcasternum (Fs) with its base at the apophyseal pit, descends directed towards the metacoxae to a articulate with them. Its greater part is secondarily fused by its anterior face with the posterior face of the base of the basisternum, while, the remaining portion is free from any sclerotica association with the basisternum . The later al angles of the distal portion of the furcasternum are modified into small articular knobs (d) for articulation with the coxae.

The furcasternum is traversed by a median longitudinal groove (mlgs) starting from the apophyseal pit to end close to its distal concave margin. The present writer regards this groove as purely secondary whose internal ridge is not visible.

Madden's (1944) description of the metasternum, like the mesosternum, is very sketchy. He finds the 'basisternum' reduced to a narrow 'precoxale' and the 'furcasternum' reduced correspondingly. Ehrlich (1963) in P. plexippus divides the entire latero-ventral plate into a small but well defined 'anepisternum' and a large 'katepisternum'. This interpretation has already been discussed earlier (page 103). Srivastava (1962) in P. demoleus finds the metasternum completely infolded and devoid of any subdivision. This idea has been discussed in connection with the mesosternum (page 103).

Endosternum.— The apophyseal pit forms the point of formation of the endosternum. Internally it is produced into the sternal apophysis (SA) forming the base of the endosternum comparable with the stem portion of 'Y' shaped endosternum of other insects. From the sides of the base come out the paired elongated furcal arms (FA). Each furcal arm runs obliquely directed towards the epimeron to fuse with its ventral portion. This is a different condition from one found in the mesothorax, where, the furcal arm fuses with the dorsal portion of the epimeron. Like the mesothorax, the metathoracic furcal arm has no association, whatsoever, with the pleural ridge.

Similarly, no connection of the furcal arm with the pleural ridge or pleural apophysis, is reported by Madden (1944) in P. sexta, Nüesch (1953) in T. polyphemus and Srivastava (1962) in P. demoleus. On the other hand, Ehrlich (1958) in P. plexippus names a similar structure as the 'secondary furcal arm', since, he shows the 'primary furcal arm' attached to a plate which he considers as an outgrowth of both the 'pleural ridge' and the 'epimeron'.

The base (SA) of the endosternum, continuing anteriorly directed, flattens out into a broad plate which is named as 'neural plate'(np). Anteriorly, the plate is notched to provide a passage, called 'neural passage' (nf) for the nerve cord. Laterally, the plate is produced into a blunt lateral process (lp). These lateral processes serve as seat of origin for the depressor of the abdomen and insertion fof interesternal muscle between the mesothorax and the metathorax. The present writer feels tempted to call these lateral processes as 'secondary furcal arms'; but the fact that these have no direct or indirect association with the pleura makes him hesitant to call them as 'secondary furcal arms'. Madden (1944) in P. sexta appears to be bold enough in showing 'anterior and posterior pairs of furcal arms'. Since he has not substantiated his interpretation, it is difficult to accept it.

The metacoxal socket in U. pulchella is as large as the mesocoxal socket. Like the latter, it is bounded

antero-laterally by the posterior margin of the pleuron; whereas, its posterior and mesal limits are formed by the intersegmental membrane and the sternum (basisternum and furcasternum) respectively. The pleural and sternal articulations of the metacoxa are identical with those of the mesocoxa.

In view of Ferris' (1950) new concept, the metathorax of U. pulchella would be as follows: The 'dorsal plate' covers the entire metatergum with its subdivisions; the 'limb bases' correspond to the pleura with their subdivisions, the basisternum and the furcasternum; the 'discriminal line' includes the mid-longitudinal ridge, sternal apophysis and its pit.

(xii) Structure of the hind-leg (Figs. 63, 64 & 68).--

The hind-leg resembles the middle-leg in almost all respects including the musculature. The coxa is comparatively smaller. The mesal half of both the proximal and distal rims is less emarginated with the result that the mesal wall is fairly broad. The basicostal suture (bcs), just before reaching the lateral angle of the distal rim (CxDArk), instead of ending there bends to run submarginal to the posterior portion of the distal rim upto its mesal angle. Therefrom, it turns upwards to ascend upto the sternal articulation (CxMArc). Thus, the basicostal suture becomes 'U' shaped. It possesses a strong basicosta (Bc). The membrane connecting the mesal half of the proximal rim of the coxa contains a

small sclerotic piece (z). A similar sclerite has been named 'coxal sclerule' by Ehrlich (1968) in the mesothorax and not in the metathorax of P. plexippus. The metafemur (FM (Fm) is smaller than the mesofemur. The metatibia (Tb) is stouter and about one and a half times longer th n the meso-tibia, with the distal end fairly broad. Besides the two marginal spurs (Tbs1), the hind-tibia also possesses another set of two spurs (Tbs2) on its ventral wall, well removed from the distal rim. The tarsus of the hind-leg is shorter than that of the fore and middle-legs.

(xiii) Musculature of the hind-wing.

Lateral paired indirect and principal depressor of the hind-wing (Figs. 65 & 69; No. 93).— It is composed of almost parallel fibres extending obliquely backwards between the middle of the lateral portion of metascutum and the stem-cum-anterior arm of third phragmanotum.

Median unpaired indirect and principal depressor of the hind-wing (Fig. 69; No. 94).— This muscle is smaller and cylindrical with fibres arising on the median portion of the scutum. Running posteriorly, it is inserted on the middle of the stem of the third phragmanotum close to the bifurcation of its arms.

The two muscles combiningly take up the responsibility of depressing the wing during flight. The contraction

of the two muscles arches the metatergum, thereby, depressing the hind-wing. Normally, there is only one such muscle in insects (L. varicornis, P. plexippus and P. demoleus). However, two muscle condition is also reported by Nüesch (1953) in T. polyphemus and Treat (1959) in C. devastator.

Indirect and principal elevator of the hind-wing (Fig. 69; No. 96).—

It is a pair of broad muscles placed centrally to all the dorso-ventral muscles. Its fibres extend between the basisternum lateral to the midlongitudinal ridge and the lateral portion of the scutum lateral to the origin of the lateral paired indirect and principal depressor of the hind-wing. This pair of muscles acts antagonistic to the depressor muscle by dearching the tergum to bring it back to its normal position. It can be compared with muscle 'dvl' of T. polyphemus and C. devastator.

Indirect and secondary elevator of the hind wing (Fig. 71; No. 96).—

This is a fan shaped muscle arising by a broad base on the dorsal half of the pleural ridge. The fibres run obliquely backwards and are inserted ontthe free end of the prealar arm. This muscle appears to be homologous to the first indirect and secondary elevator of the fore-wing but has shifted its origin from the basalare apodeme to the pleural ridge. On contraction, it pulls the anterior region of the tergum downwards, thereby, helping in its dearching. This is a new muscle in Lepidoptera.

First extensor of the hind-wing (Figs. 70 & 71; No. 97).— This thick muscle arises on the marginal inflection of coxa genuina. Running ventro-dorsally, its parallel fibres end on the posterior portion of the head of basalare apodeme. This muscle is similar to muscle 'pv2' of T. polyphemus and C. devastator and to muscle No. 100 of D. plexippus.

Second extensor of the hind-wing (Figs. 70 & 71; No. 98).— The fibres of this thin muscle arise anteriorly on the arm of the basisternum. Ascending obliquely in postero-anterior direction, the fibres converge on a short tendon inserted on the anterior portion of the head of basalare apodeme. It can be taken as muscle 'pv1' of T. polyphemus and C. devastator and muscle No. 99 of D. plexippus.

The contraction of the two extensors pulls down the basalare. This pull is transmitted to the wing with the result that the latter is extended out.

Accessory extensor of the hind-wing (Figs. 57 & 70; No. 99).— It is a slender muscle which arises on the flap like projection of the mesofurcal arm. The muscle takes up an oblique antero-posterior course and crossing the segmental limit, ends on the outer surface of the head of basalare apodeme of the metathorax. This muscle works in conjunction with the two extensors of the hind-wing, thereby, completely extending the latter. It is comparable with the 'sterno-basalare muscle' of Lepidoptera (Maki, 1938). Nuesch (1953) in T. polyphemus describes a similar muscle with the mesothoracic muscles.

First flexor of the hind-wing (Fig. 72; No. 100).--- The first flexor of the hind-wing is a thick muscle composed of three distinct bundles, which are inserted on the anterior process of the third axillary sclerite. The first bundle (a) is the smallest and arises on the posterior aspect of the pleural wing process; the second bundle (b) is the largest and originates close to the incurved portion of the mesal margin of episternum; while, the fibres of the third bundle (c) arise on the posterior aspect of the dorsal half of pleural ridge. On contraction, the muscle pulls the third axillary sclerite. This pull on the third axillary sclerite is responsible for the flexion of the hind-wing. Similar muscles (pd2abc) are shown by Nüesch (1953) and Treat (1959) in T. polyphemus and C. devastator, respectively. Ehrlich and Davidson (1961) in D. plexippus and Srivastava (1962) in P. demoleus, however, report two separate muscles composed of only one bundle each.

Second flexor of the hind-wing (Fig. 71; No. 101).--- This is a long thick muscle arising on the lateral half of the distal rim of meron. Ascending obliquely, its fibres end on the submarginal inflection of the body of subalare. On contraction, the muscle pulls down the subalare. This pull is transmitted to the second axillary sclerite through the ligament connecting the anterior end of the body of subalare with the second axillary sclerite. Originally, it is a leg muscle, but the close association of the subalare with the

second axillary sclerite makes the muscle to act as a flexor of the hind-wing. This is similar to muscle 'pv4' of T. polyphemus and C. devastator. Srivastava (1962) in P. demoleus takes it as aleg muscle consisting of two distinct bundles (muscle No. '112a,b').

Accessory flexor of the hind-wing (Fig. 69; No. 102).— This muscle is fanshaped and is inter-segmental. It arises on the postalar bridge of the mesothorax and ends on the base of the pleural wing process. On contraction, it will pull the latter forward. Since the pleural wing process fits into the ventral surface of the second axillary sclerite, the latter will be tilted so as to flex the hind-wing. A similar muscle (No. 107) is present in P. demoleus.

Metathoracic furco-pleural muscle (Fig. 72; No. 103).— This muscle corresponds to the mesothoracic furco-pleural muscle and is, likewise, fan shaped. It arises by a long thin tendon on the ventral end of the pleural ridge close to its articulation with the coxa. Ascending obliquely, backwards it ends by a broad base on the anterior face of the furcal arm. This unusual change in the form of insertion by broad base should not come in the way of assigning function to the muscle as absolutely identical condition has been attributed to the 'second ventral dilators of the anterior pharynx' in S. deesae where, too, the condition of insertion is not allowed to cause difficulty in assigning function to the muscle. Its homologue

in the mesothorax presents exactly the opposite shape, i.e., it arises by a broad base and converges to end by a long tendon. The contraction of this muscle protects the meta-endosternum from undergoing any distortion due to the working of the third remotor of coxa. A similarly shaped muscle exists in P. polyphemus and C. devastator, whereas, in P. demoleus it is shown to be inserted by a long thin tendon.

(xiv) Musculature of the hind-legs.

Like the middle coxa, the hind coxa is also provided with both the pleural and the sternal articulations and, hence, its movements are similar to those of the middle coxa. The various movements are controlled by the following muscles.

First promotor of coxa (Fig. 72; No. 104).— This muscle is different from its counterpart of the meso coxa in origin and shape. It is a thick short muscle composed of, more or less, parallel fibres which take their origin on almost the entire sternopleural suture. The fibres take up a backwardly directed course to end anteriorly on the lateral half of the proximal rim of coxa gemina close to the pleural articulation but lateral to the origin of the first extensor of the hind-wing. It may be compared with the fan shaped muscle ('pv6') of P. polyphemus and C. devastator.

Second promotor of coxa (Fig. 70; No. 105).— It is a fairly thick muscle which arises anteriorly on the lateral

portion of the scutum, lateral to the origin of the indirect and principal elevator of the hind-wing. The fibres running almost vertically downwards converge to end almost equally removed from the pleural and sternal articulations of the coxa, on the marginal inflection of the proximal rim of coxa gemina. It is homologous to muscle 'dv2' of T.polyphemus and C.devastator. Ehrlich and Davidson (1961) in D.plexippus record two such muscles (Nos. 89 and 95) arising on either side of the 'scutal ridge'.

Third promotor of coxa (Fig. 73; No. 106).— This short fan shaped muscle arises posteriorly on the horizontal portion of the midlongitudinal ridge. The fibres, converging to form a small tendon, are inserted on the mesal half of the proximal rim of coxa gemina close to its sternal articulation. This muscle can be taken as muscle 'st1' of T.polyphemus and C.devastator and as muscle No. 86 of D.plexippus.

The simultaneous contraction of the above three promotors will move the coxa forward and, consequently, the entire leg is promoted.

First remotor of coxa (Fig. 70; No. 107).— It is a large thick muscle arising on the posterior half of the lateral portion of the scutum, lateral to the origin of the second promotor of the coxa. The fibres, descending obliquely in an antero-posterior direction, converge to end on the inner

surface of the lateral wall of meron near its distal rim. This is comparable with muscle 'dv4' of T.polyphemus.

Second remotor of coxa (Fig. 70; No. 108).— This thick muscle arises on the lateral portion of the scutum posterior to the origin of the first remotor of coxa, and, running parallel to the latter, gets inserted on the mesal half of the proximal rim of coxa (meron) equidistant from the pleural and sternal articulations of the coxa. It is similar to muscle 'dv5' of T.polyphemus and muscle No. 91 of D.plexippus. Treat (1959) in C.devastator finds only a single muscle ('dv4(5)') and compares it with the two muscles ('dv4' and'dv5') of T.polyphemus.

Third remotor of coxa (Fig. 73; No. 109).— This is a broad muscle with almost parallel fibres. Arising on the vertical portion of the midlongitudinal ridge of basisternum, it runs posteriorly to end on the mesal half of the proximal rim of coxa (meron) close to its sternal articulation. In T.polyphemus,such a muscle is shown to arise on the 'postcoxal bridge'.

The above three remotor muscles act antagonistic to the promotor muscles and, thus, on contraction, swing the coxa backwards. This, consequently, pulls back the entire leg from its forward position.

First levator of trochanter (Figs. 74 & 75; No. 110).— It is a thick muscle whose fibres arise on the undersurface of

the marginal inflection of coxa gemina, as well as, on the anterior face of the basicosta. The fibres converge to form a small tendon which is inserted on the dorsal apodeme of the trochanter.

Second levator of trochanter (Figs. 74 &75; No. 111).— This small fan shaped muscle takes its origin posteriorly on the mesal half of the distal rim of coxa (meron). The fibres converge to end on the dorsal half of the proximal rim of trochanter posterior to the dorsal apodeme. It may be taken to correspond with muscle 'ex3' of T. polyphemus.

The contraction of the above two muscles, in conjunction, levates the trochanter and, consequently, the rest of the leg is raised.

First depressor of trochanter (Fig. 69; No. 112).— It is a long thick muscle consisting of two distinct bundles (a,b) which arise on the lateral portion of the scutum just posterior to the origin of the indirect and prieipal elevator of the hind-wing. The two bundles, running dorso-ventrally, are inserted by a common base dorsally at the proximal end of the ventral apodeme of trochanter. It is similar to muscle 'dv3' of T. polyphemus and C. devastator. In D. plexippus, the the two bundles of this muscle are taken as two separate muscles (Nos. 90 and 96).

Second depressor of trochanter (Figs. 73, 74, & 75; No. 113).— This muscle is composed of parallel fibres which originate on

the undersurface of the neural plate of meta-endosternum. The fibres descend obliquely to get inserted on the posterior face of the ventral apodeme of trochanter distal to the insertion of the first depressor. It is homologous to muscle 'st2' of T.polyphemus and to muscle No. 87 of D.plexippus.

Third depressor of trochanter (Figs. 74 & 75; No. 114).— This slender muscle arises anteriorly on the marginal inflection of coxa genuina and is inserted on the anterior face of the ventral apodeme of trochanter. It can be taken as muscle 'cx1' of T.polyphemus and C.devastator. In D.plexippus, two such muscles (Nos. 104 and 105) are shown to occur.

Fourth depressor of trochanter (Fig. 73; No. 115).— This fan shaped muscle arises anteriorly on the mesal half of the proximal rim of coxa (coxa genuina) anterior to its sternal articulation. The fibres converge to form a tendon which is inserted at the base of the ventral apodeme of trochanter. This muscle has not, so far, been reported in Lepidoptera.

Accessory depressor of trochanter (Figs. 70 & 71; No. 116).— This long muscle, arising on the undersurface of the basalare apodeme, is inserted on the anterior face of the ventral apodeme of trochanter. This muscle should not be regarded as an extensor muscle for the hind-wing, since, its action is likely to affect the trochanteral apodeme much easily than the basalare apodeme. It is similar to muscle 'pv3' of T.polyphemus

and C. devastator and to muscle No. 101 of D. plexippus.

The above five depressor muscles combiningly work on the ventral half of the proximal rim of trochanter which is made to bend upwards. This, consequently, results in pulling down the distal end of the trochanter and, thus, the entire leg is depressed.

(xv) Thoracic Wings and their Sclerites.

The wings of U. pulchella are held over the abdomen in repose, and are densely covered over with scales. The fore-wing is white with scattered scarlet and black spots; besides a series of black spots on its outer margin. The undersurface of the basal half of the wing possesses the retinaculum. The broad hind-wing is semi-diaphanous. It possesses two black spots in the middle, whereas, a large irregular black submarginal band is stretched along its outer and posterior margins. The plain anterior margin, at its base, possesses the frenulum which is engaged in the retinaculum.

Regions of the fore-wing (Fig. 78).— The fore-wing can be differentiated into the usual wing regions due to the presence of folds. The largest of all the regions is the remigium (R) which contains all the veins, from costa to the cubitus, including their cross-veins. It is anteriorly limited by the anterior margin of the wing and posteriorly by the vannal

fold (vf) which separates it from the vannus (V). The latter, containing the anal veins, is limited anteriorly by the vannal fold and posteriorly by the posterior margin-cum-jugal fold. The posteriormost region of the wing is the jugum (J) which is confined posterior to the jugal fold (jf).

Venation of the fore-wing (Figs. 76, 77 & 78).— The costa (C) is fairly prominent but does not extend beyond three-fourths of the anterior margin of the wing. The subcosta ends on the anterior margin of the wing slightly distal to the ending of the costa. It is, althrough, fused with the first branch of the radial vein. Thus, the second vein is a compound one (Sc+R1). Its base (Scb) extends proximally and is drawn out into a narrow process (Scp) which articulates with the first axillary sclerite. The radial sector (Rs) divides into two branches in the apical half of the wing. The anterior branch (Rs) continues as the radial sector; whereas, the posterior branch redivides to give rise to the second, third, fourth and fifth branches of the radial sector (R2, R3, R4 & R5). The media is reduced, having lost its main stem. Its first branch (M1) arises from the point of bifurcation of the radial sector. The other two branches (M2 and M3) extend from the posterior distal angle of the discal cell (D). The cubitus1(Cu1) is prominent, and, almost in its middle, bifurcates into two branches called as cubitus1a and cubitus 1b (Cu1a and Cu1b). The first anal vein(IA) is distinct; whereas,

the second one (2A) is reduced to a short vein lying submarginal to the posterior margin of the wing.

There are four cross-veins; the anterior most is the radio-medial cross vein (r-m) which connects the posterior branch of the radial sector with the first branch of the media. The second cross-vein, called the discal vein (d) partly forms the distal limit of the discal cell. It is a weakly developed cross-vein running between the first and second branches of the media. The medial cross-vein (m) is short and connects the bases of the second and the third branches of the media. The last cross-vein is present between the media3 and the cubitusla, and, hence, is called the medio-cubital cross-vein (m-cu).

Nomenclature of the cells of the fore-wing (Fig. 76).

'Costal' cell (C).— It is a long narrow cell limited anteriorly by the 'costa' and posteriorly by the fused 'subcosta' and the 'radiusl'.

'Radial 1' cell (R1).— It is also long and narrow whose anterior and posterior limits are formed by the fused 'subcosta' and the 'radiusl' and the'radial sector', respectively.

'Discal' cell (D).— This prominent cell, located in the basal three-fourths of the wing, is distally broad while proximally, it becomes narrow. The proximal three-fourths

of the 'radial sector' forms its anterior boundary. Posteriorly, it is limited by the main stem of the 'cubitus1' and a portion of the 'cubitus1a'. Distally, the cell is bounded by the 'discal vein', the 'medial' cross-vein and the 'medio-cubital' cross-vein. This cell is a compound one formed by the fusion of the 'radial' and the'medial' cells.

'Radial sector' cell (Ŕs).— It is long and narrow and is confined to the apical half of the wing. The distal one-fourth of the 'radial sector' serves as its anterior limit, whereas, posteriorly it is bounded by the 'radius2'.

'First Radial2' cell (1Ŕ2).— It is the shortest of all the cells and is anteriorly surrounded by the proximal portion of the 'radius2'. The 'radio-medial' cross-vein, in combination with the proximal portion of the 'medial', becomes its posterior border.

'Second Radial2' cell (2Ŕ2).— This cell is longer than the former cell and is bounded anteriorly and posteriorly by the 'radius2' and the'radius3' respectively.

'Radial3' cell (Ŕ3).— It is smaller but wider than the preceding cell. Anteriorly and posteriorly, the cell is limited by the 'radius3' and the 'radius4' respectively.

'Radial4' cell (Ŕ4).— This cell is anteriorly bounded by a portion of the 'radius3' and the entire 'radius4'; the

posterior limit being formed by the'radius5'.

'Radial5' cell (R5).— The 'radius5', the 'radio-medial' cross-vein and a portion of the'radius2' combiningly form the anterior margin of this cell. Posteriorly, it is enclosed by the 'medial'.

'Medial1' cell (M1).— This large cell lies between the 'medial' and 'media2'. Proximally, it is separated from the discal cell by the 'discal' vein.

'Medial2' cell (M2).— The 'medial2' cell is limited anteriorly and posteriorly by the 'media2' and the 'media3' respectively. The short 'medial' cross-vein becomes its proximal border.

'Medial3' cell (M3).— The 'media3' and the 'cubitus1a' serve as the anterior and posterior borders of this cell. It is proximally demarcated from the discal cell by the 'medio-cubital' cross-vein.

'Cubital1a' cell (Cu1a).— This large cell is anteriorly bounded by the 'cubitus1a' and posteriorly by the 'cubitus1b'.

'Cubital1b' cell (Cu1b).— It is the largest cell of the fore-wing whose anterior border is contributed by the main stem of 'cubitus1' and the entire 'cubitus1b'. The posterior limit is formed by the 'first anal' vein. This cell possesses the vannal fold.

'Anal' cell (Á).— The long and narrow 'anal' cell is confined between the 'first anal' vein and the posterior margin of the wing. It is a compound cell formed by the fusion of the two anal cells. However, in the proximal region, the two anal cells can be differentiated due to the presence of the reduced 'second anal' vein. The jugal fold traverses this cell.

Articulation of the fore-wing (Figs. 46, 47, 77 & 78).— The fore-wing of U. pulchella is attached to the lateral margin of the mesonotum through extensive axillary membrane, which contains the pteralia and the epipleurites. The wing is supported on the tergum and the pleuron by anterior and posterior notal wing processes and the pleural wing process. The posterior margin of the wing is in continuity with axillary cord (Axc) which forms the posterior limit of the wing base.

Pteralia.

First axillary sclerite (1Ax).— The first axillary sclerite is quadrilateral shaped with margins (sides) deeply emarginated. It lies obliquely in the axillary membrane (Wab) close to the lateral margin of the tergum. The posterior angle (A) of the anterior notal wing process fits into the concavity of the mesal (inner) margin (be) of the first axillary sclerite; whereas, the rest of the margin abuts against the surface of the anterior notal wing process between its anterior and posterior angles (N,A). The free lateral (outer)

margin (da) of the first axillary sclerite provides attachment to the axillary membrane and is devoid of sclerotic connection. The distal two-thirds of the anterior margin (cd) provides resting surface to the anterior angle (e) of the second axillary sclerite. The posterior margin (ab) rests on the pseudo-anterior notal wing process. Because of close association of mesal and posterior margins of the first axillary sclerite with the true and the pseudo-anterior notal wing processes, the postero-mesal angle (b) of the former enters into the gate of the axillary fissure of the scutum.

Second axillary sclerite (2Ax).— All the four margins of the second axillary sclerite are concave with the four angles clearly rounded. The anterior angle (e) rests on the concave anterior margin (cd) of the first axillary sclerite; whereas, the posterior angle (f) articulates with the concavity (o) present in the anterior margin of the third axillary sclerite. The dorsal angle (g) is free. The ventral angle (h) articulates with the pleural wing process. Thus, it is very close to the generalised condition in which the second axillary sclerite possesses the dorsal, ventral and posterior articulations.

Third axillary sclerite (3Ax).— The third axillary sclerite is almost boat shaped having the bottom (posterior margin) convex and the face (anterior margin) almost concave.

It is lying obliquely in the axillary membrane with both the inner (p) and outer (k) angles acute. The anterior margin (l), somewhere in the middle, is produced into a curved process (n) which articulates with the fourth axillary sclerite. In between the process and the outer angle, the the anterior margin is emarginated (o) to provide a socket for the articulation of the second axillary sclerite. It is only the inner angle (p) which provides insertion to the first flexor of the fore-wing.

Fourth axillary sclerite (4Ax).— This is an oblong sclerite intervening between the third axillary sclerite and the posterior notal wing process. The outer end (r) of this sclerite is concave for the articulation of the third axillary sclerite. The inner end (s) is narrowly convex to be apposed to the posterior notal wing process.

Humeral plate (HP).— It is a small, more or less, triangular lightly sclerotised plate situated on the anterior margin of the wing base. The humeral plate is separated from the base of the costa by a narrow membranous strip.

Median plates (ḿ,m̋).— There are two well developed median plated lying in the axillary membrane. The anterior plate (ḿ) is large and is constricted in the middle. The proximal half of the plate lies posterior to the base of the fused 'subcosta' and 'radius1'; whereas, the distal half

tapers to lie in very close proximity of the posterior median plate (m^{3}). The latter is an elongated plate which is proximally in close association with the third axillary sclerite; whereas, distally it ends near the base of the 'cubitus1'. The posterior margin of the posterior plate lies close to the base of the 'first anal' vein.

Epipleurites.

Basalare (Ba).— The basalare is a small four-sided sclerite resting by its ventral margin on the anterior margin of the mesopleuron anterior to the pleural wing process. Its mesal surface is distinctly concave. The anterior margin of the basalare lies close to the prealar arm; the dorsal margin faces the tegular arm, while, the posterior margin is in conjunction with the drawn out base of the fused 'subcosta' and the 'radius1'. The ventral margin of the basalare is drawn out into a short process whose inner free end is fused with the basalare apodeme (BaAp). The latter is broad and semi-circular whose inner surface is concave to provide insertion to the first and second extensors of the fore-wing. The convex outer surface is fused with the entire anterior and a portion of the mesal margins of anepisternum. Madden (1944) in P. aenea finds that the 'basalare' is a small partially detached sclerite whose basal portion is considered by him to be represented by a fold in the dorsal margin of the 'anepisternum'. Similarly, Ehrlich (1968) in D. plexippus finds it to be a small diamond

shaped sclerite whose anterior corner receives a tendon from a lightly sclerotised apodeme.

Subalare (Sa).— The subalare is comparatively a larger sclerite embedded in the axillary membrane (Wmb) between the two arms of the 'U' shaped epimeron and is, more or less, boat shaped. Its dorsal margin (face) is concave (dm) and has undergone marginal inflection (mi). A similar inflection is named 'wing like apodeme' by Ehrlich (1958) in P. plexippus. Madden (1944) in P. sexta does not report any such inflection. The mesal angle (ma) of the subalare is directed towards the pleural wing process and is in membranous connection with the ventral angle (h) of the second axillary sclerite. Madden (1944) in P. sexta reports a 'second subalare' behind the subalare proper, which is, however, not present in U. pulchella nor is reported by Ehrlich (1958) in P. plexippus.

Regions of the hind-wing (Fig. 79).— The regions of the hind-wing are basically identical with those of the fore-wing. The only difference lies in the vannal region which is posteriorly bounded by the jugal fold alone.

Venation of the hind-wing (Figs. 79, 80 & 81).— Like other Lepidoptera (vide Comstock, 1918), the costa of the hind-wing in U. pulchella is entirely lost and the anterior margin of the wing is plain. Proximally, the anterior margin possesses a small sclerotic piece (Cs), called by Comstock (1918) as the

'costal sclerite'. This sclerite provides attachment to the frenular spines (ff). The subcosta and the radial sector arise from a common stem which bifurcates in the basal one-fourth of the wing. The anterior branch is a fusion product of the subcosta and the radius1(Sc+R1); whereas, the posterior branch becomes the radial sector (Rs). Like the fore-wing, the base of the subcosta + radius1 is drawn out into a process (Scp) for articulation with the first axillary sclerite. The main stem of the media is lost, and its first branch (M1) arises from the middle of the radial sector. The other two branches (M2 and M3) of thw media extend from the posterior distal angle of the discal cell. The cubitus1 (Cu1) divides, in the basal half of the wing, to give rise to its two branches, i.e., the cubitus1a (Cu1a) and the cubitus1b (Cu1b). Unlike the fore-wing, the two anal veins (1A and 2A) are fairly prominent.

The hind-wing does not possess the radio-medial cross-vein, which is present in the fore-wing. The discal vein (d) is identical to that of the fore-wing. The medial (m) cross-vein is comparatively more prominent; whereas, the medio-cubital cross-vein (m-cu) is short but distinct.

Nomenclature of the cells of the hind-wing (Fig. 79).—

'Marginal' cell (mc).— This is the anterior most cell of the hind-wing and can be homologised with the 'costal' cell of the fore-wing. It is anteriorly bounded by the anterior

margin of the wing, whereas, its posterior border is formed by the fused 'subcosta' and the 'radius1'. Thus, the cell becomes a compound one due to the fusion of the costal and the subcostal cells.

'Radial1' cell (R1).— It is enclosed between the fused 'subcosta' and the 'radius1' and the 'radial sector'.

'Radial sector' cell (Rs).— The 'radial sector' cell is smaller than the preceding two cells. Its anterior limit is formed by the 'radial sector' while the 'medial' limits it posteriorly.

'Discal' cell (D).— This prominent cell is located in basal half of the wing. The anterior border is formed partly by the common stem of the 'subcosta' and'radius' and partly by the proximal one-third of the 'radial sector'. Distally, the cell is limited by the 'discal' vein, the 'medial' cross-vein and the 'medio-cubital' cross-vein. The posterior limit of the cell is the main stem of the 'cubitus1' and the proximal half of the 'cubitusla'. Like the fore-wing, the discal cell of the hind-wing is also compound.

'Medial1' cell (M1).— It is almost rectangular in shape with the anterior and posterior limits represented by the 'medial' and the 'media2', respectively.

'Medial2' cell (M2).— The 'medial2' cell is anteriorly bounded by the 'media2', whereas, the posterior boundary ~~is~~

is formed by the 'media3'. Proximally, it is closed by the 'medial' cross-vein.

'Media3' cell (Ḿ3).— This is identical in shape and size to the preceding cell. Its anterior and posterior limits are the 'media3' and the 'cubitusla' respectively. Proximally, the cell is limited by the 'medio-cubital' cross-vein.

'Cubitalla' cell (Cúla).— The 'cubitusla' and the 'cubituslb' respectively, represent the anterior and posterior borders of this cell.

'Cubitallb' cell (Cúlb).— It is the largest cell of the hind-wing and is anteriorly bounded by the main stem of the 'cubitusl', as well as, by the entire 'cubituslb'. The posterior limit is represented by the 'first anal' vein. The vannal fold runs through the middle of this cell.

'Anterior anal' cell (1Á).— The 'anterior anal' cell lies between the first and the second 'anal' veins.

'Posterior anal' cell (2Á).— It is a narrow cell, shorter than the preceding cell. It is limited anteriorly by the second 'anal' vein and posteriorly by the posterior margin of the wing and contains the jugal fold.

Articulation of the hind-wing (Figs. 63, 64, 80 & 81).— Like the fore-wing, the hind-wing is also attached to the side of

metatergum through extensive axillary membrane (Wm) in which are embedded the pteralia and epipleurites. The anterior and posterior notal wing processes support the wing dorsally while the pleural wing process provides the ventral support. The axillary cord (Axc) of the wing connects it with the tergum. It also forms the posterior limit of the wing base. There are only three axillary sclerites.

Pteralia.

First axillary sclerite (1Ax).— The first axillary sclerite is, more or less, triangular whose outer wall (uv) and the base (ut) are concave. The inner wall (tv) is convex. The sclerite lies obliquely in the axillary membrane of the wing base, close to the lateral margin of the tergum. Its inner basal angle (t) articulates with the anterior notal wing process, while, the outer basal angle (u) lies in close association with the second axillary sclerite. The vertex (v) is modified into a depression to provide articulation to the basal process of the subcosta + radius1 (Scp). The inner wall of the sclerite abuts against the pseudo-anterior notal wing process. The concave outer wall functions as a lap for the broad mesal angle of the second axillary sclerite.

Second axillary sclerite (2Ax).— The second axillary sclerite is almost quadrilateral shaped. The unequal extensions of the angles impart it an irregular shape. The anterior angle (w) is produced and narrowly rounded to develop

association with the base of the fused subcosta and the radiusl (Scb). The posterior angle (x) is acute and articulates with the outer basal angle (u) of the first axillary sclerite. The mesal angle (y) is broadly rounded and rests in the lap of the corresponding outer wall (uv) of the first axillary sclerite. The acute lateral angle (z) dives down to articulate with the third axillary sclerite. The ventral surface of the sclerite is produced into a short process (Ap) which receives the ligament of the subalare. Close to the process, the ventral surface is distinctly concave to provide articulation to the pleural wing process through thin ligamentous processes (strands).

Third axillary sclerite (3Ax).-- The third axillary sclerite is roughly boat shaped lying in meso-lateral position in the axillary membrane. Its mesal surface (BC) is emarginated to form two processes. The posterior among them (C) articulates with the posterior notal wing process, while, the anterior (B) one dives to become point of insertion for the first flexor of the hind wing. The anterior surface (BD) is concave. The latero-posterior surface (DLC) is convex with its lateral portion protruding out into a blunt process (L). This process is flattened and lies in close association with the base of the first anal vein. The lateral end of the sclerite (D) is produced into a short articular process which articulates with the lateral angle (z) of the second axillary sclerite.

Humeral plate (HP).— It is a narrow elongated sclerite present on the anterior margin of the wing base. In its proximal half, the sclerite is slightly constricted. Distally, the humeral plate is closely associated with the costal sclerite and develops ligamentous connection with the basalare.

Median plate (m).— The hind-wing possesses only a single median plate which lies embedded in the axillary membrane posterior to the base of the fused subcosta and the radius1. Its anterior margin is concave and is produced into an anteriorly directed process; whereas, the posterior margin is convex. The lateral angles are drawn out into anteriorly directed processes.

Epipleurites.

Basalare (Ba).— The metathoracic basalare provides a different shape from that of the mesothorax. It is a small club like sclerotic structure with the base articulating with the shallow concavity (Bac) present at the junction of the dorsal and anterior margins of episternum. The club develops ligamentous connection with the humeral plate of the wing base. The basalare possesses a funnel shaped apodeme (BaAp) whose head (F) receives the fibres of the extensor muscles of the hind-wing. The neck(N) of the apodeme is drawn out to fuse with the basalare in the middle of its anterior surface. Except Treat (1959), the other workers on Lepidoptera (Madden, 1944, in P. sexta; Ehrlich, 1958, in D. plexippus; Srivastava,

1962 in P. demoleus) have shown similar basalare in their respective insects. According to Treat (1959) in C. devastator, the basalare is lobular and receives its muscles direct on its body, since it has no apodeme. It appears that the 'basalare pad' of Shepard (1930) in Lepidoptera and of Madden (1944) in P. sexta has been called as 'basalare' by Treat (1959). In U. pulchella, however, there is no such pad. Treat (1959) in C. devastator shows a sclerotic bar, which, in position and shape is identical to the basalare of U. pulchella, and calls it 'tergal arm'. He also records it in very close association with the basalare. Keeping in view the details regarding basalare and the so called 'tergal arm' in C. devastator, the present writer suggests that Treat (1959) may rename the 'tergal arm' and the 'basalare' as basalare and basalare apodeme respectively in his insect.

Subalare (Sa).— The subalare is spoon shaped and lies embedded in the wing base below the posterior notal wing process. The body of the sclerite is expanded and lies near the pleural wing process. The stalk (SaSt) is elongated and narrow with its tip articulating with the concavity borne by the free end of the posterior arm of epimeron. Anteriorly, the apex of the body of subalare is in ligamentous (Lig) connection with the second axillary sclerite. Its dorsal margin possesses a submarginal groove (gr) which is internally represented by a distinct ridge (grR). The fibres of the second flexor muscle of the hind-wing are inserted on this ridge.

The Wing-coupling Apparatus. (Figs. 77, 79, 80 &81).—

The wing-coupling apparatus is of the 'frenate' type. It differs in males and females, thereby, showing sexual dimorphism. It consists of a 'frenulum' and a frenular hook or 'retinaculum'. In the male, the 'frenulum' (fm) is a stout spine, which, arising from the costal sclerite of the hind-wing, is directed beneath the fore-wing. The 'retinaculum' (rh) originates on the undersurface of the fore-wing, from the fused 'subcosta' and the 'radius'. It is a membranous curved lobular structure which serves as a catch for the frenular spine. In the female, the 'frenulum' (ff) consists of three or four spines which are smaller and narrower than the spine of the male. The frenular spines of the female have their rounded bases in small membranous areas in the costal sclerite. The 'retinaculum' in the fore-wing is reduced to a group of somewhat stiffened scales arising near the 'cubitus' and serve to hold the frenular spines. The wing-coupling apparatus ensures a better coordination of the movements of wings during flight.

3. THE ABDOMEN.

The abdomen of U. pulchella is elongated and cylinderical but changes to globular shape when fully fed. It consists of ten segments with the last two segments modified to cope with the development of the genital complex of the sexes concerned. The abdominal terga and sterna, in both the sexes, are sclerotised plates of different sizes, excepting the first segment, which is mostly membranous. Likewise, the eighth segment in the male is reduced to a membranous annulus. The segmental plates are connected through extensive intersegmental membranes but this does not interfere with the linear partial overlapping of the plates. The pleural region is mostly membranous. It is completely exposed and does not permit any sideway overlapping of terga and sterna. The seven pairs of abdominal spiracles are lodged in it. The detailed study of the abdominal segments is carried out giving full recognition to their modifications based on the presence of the genital complex. Accordingly, the entire abdomen is subdivided into three regions, viz., pre-genital, genital and post-genital regions.

(1) The Pre-genital Region (Figs. 63, 64, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91 & 113).

The pre-genital region consists of eight segments. It is the longest and broadest region of the abdomen providing space for greater parts of the internal viscera.

Pre-genital terga.— The first tergum (IT) is wider than long, as well as, extensively membranous. Its short anterior margin is distinctly sclerotised into a narrow sclerotic band (SclIT). Similarly, the lateral margins have undergone sclerotisation to form sclerotic lateral tergites (lt), separating the tergum from the pleura (PlMmb). These lateral tergites are devoid of any external groove and run obliquely between the secondary plate of the third phragmanotum (ag) and the anterior margin of the second tergum (IIT). These are fused at both ends with the structures concerned. Since the lateral areas of the tergum are bent downwards (l), its lateral margins come to lie underneath the main membranous portion of the tergum. This, consequently, gives a deceptive subtriangular shape to the tergum. Madden (1944) in P. sexta shows simple sclerotic lateral limits of the first tergum with longitudinally running 'tergopleural grooves'. Ehrlich (1958) in P. plexippus regards the first tergum as almost entirely sclerotised with distinct 'tergal grooves' near its lateral margins. Posteriorly, the membranous tergum is continuous with the anterior margin of the acrotergite (atg) of second tergum.

Typical tergum.— A tergum (T) is a rectangular sclerotised plate wider than long. Anteriorly, it is traversed by a prominent antecostal suture (acs) with a corresponding internal antecosta (Ac). The tergum, therefore, is divisible into an anterior feebly sclerotised preceding inter-tergal plate

(acrotergite) and a posterior segmental tergum. The latter has been called 'scutum' by Alam (1963) in S. deesae. The acrotergite (atg) is always placed in the lap of the preceding tergum (T). The posterior margin of the tergum is separated from the following tergum by extensive inter-tergal membrane. Keeping the whole description in consideration, the third tergum (IIIT) may be taken as a typical tergum.

The second tergum (IIT) is similar to the third tergum except for a few minor variations. The antecosta (ac) is laterally produced into two lobes (acl). Laterally, the second tergum is traversed by a submarginal incomplete secondary groove (z).

The fourth, fifth and sixth terga (IV-VIT) are identical to the typical tergum, differing only in size. The seventh tergum (VIIT) differs from the typical tergum in being short. In the female, the seventh tergum has lost the acrotergite and its anterior margin (amT7) is greatly thickened to give attachment to the muscles.

The eighth tergum (VIIIT) of the male has become completely membranous and is anteriorly limited by its faintly sclerorised anterior margin (amT8). A secondary sclerotic line (dl) medially connects the anterior and posterior margins of the tergum. Along with its membranous pleura and the sternum (VIIIS), the eighth tergum forms a membranous annulus

which lodges the male genitalia within it. Ehrlich (1958) in D. plexippus shows sclerotic eighth segment consisting of distinct tergal and sternal plates and puts it among the genital segments. Srivastava (1960) in Leucinodes orbonalis Guen., also regards the eighth segment to have contributed to the formation of the genital complex. It is interesting to find Ehrlich (1958) and Srivastava (1960) deviating from the hitherto uncontested fundamentals involved in the formation of the male external genitalia in insects . Forbes (1939) in Sentis arctica and Madden (1944) in P. sexta also find sclerotic eighth segment but have excluded it from the responsibility of forming the genitalia.

Normally, the genital region of the female insects consists of the eighth and ninth segments, but in H. pulchella, the eighth segment does not contribute at all towards the formation of external genitalia. It is, therefore, included in the pre-genital region. The tergum of the eighth segment (VIIIT) lies completely telescoped into the seventh tergum (VIIT) and is separated from the latter by extensive inter-tergal membrane. Similarly, its posterior margin is in communication with the dorsum of the abdominal apex (pOvp) through broad inter-segmental membrane. The nature of the inter-segmental conjunctiva affords the opportunity of protrusion to the abdominal apex at the time of oviposition. The eighth tergum is a simple sclerotic plate devoid of the antecostal suture.

Similar one piece eighth tergum has been shown by other workers (Madden, 1944 in P. sexta; Klots, 1956 in Rhagodia emargana F., and Stegasta bosquella Ch.; and Srivastava, 1960 in L. orbonalis) except Ehrlich (1958) in D. plexippus where the eighth tergum is shown to be represented by two lateral plates. The antero-lateral angle (f) of the eighth tergum is obliquely produced forwards to fuse with the drawn out antero-lateral angle of the corresponding sternum (g). This fused part becomes the segmental apodeme and for brevity sake is termed as anterior apodeme (aap). It runs anteriorly directed upto the posterior one-third of the seventh tergum. The protractor and retractor muscles of the eighth segment are inserted on it. Srivastava (1960) in L. orbonalis shows an almost similar eighth tergum except that he uses the term 'anterior apophysis'. Norris (1932) in Plodia interpunctella Hb., also takes it as 'anterior apophysis', and shows it in articulation, instead of sclerotic contiguity, with the eighth tergum. Perhaps, she means that the eighth sternum does not contribute in its formation. Similarly, Klots (1956) in R. emargana and S. bosquella terms it 'anterior apophysis' and considers it exclusively tergal in origin. Madden (1944) in P. sexta, however, shows that the union of the eighth tergum and sternum invaginates to form a 'tendon'.

Pre-genital sterna.— All the eight sterna are arranged in the normal way with extensive inter-sternal membranes. The first sternum (IS) is almost completely membranous except a

pair of elongated narrow bar like sclerites (ls) placed obliquely in antero-posterior direction. This sclerotic bar is broad anteriorly where it is partly fused with the ventral surface of the posterior arm (pE) of meta-epimeron. Its tapering curved posterior end (c) is connected with the antero-lateral angle (d) of the second sternum (IIS). This association helps in the movements of the abdomen. Madden (1944) in P. sexta shows that the first sternum is fused with the second sternum to form a wide plate beneath the first and the second terga.

Typical sternum.-- The third sternum (IIIS) is taken as the typical sternum. It is a rectangular plate with the antecostal suture (acs) demarcating a narrow acrosternite (ast).

In the female, the fourth to sixth sterna (IV&VIS) and in the male, fourth to seventh sterna (IV&VIIS) are identical to the typical sternum. The second sternum (IIS) in both the sexes, seventh and eighth (VII-VIIIS) in the female and the eighth (VIIIS) in male have undergone some modifications. The anterior margin of the second sternum is distinctly emarginated (ema) in the middle with the antero-lateral angles (d) curved and produced forwards. Anteriorly, the second sternum possesses the antecostal suture (acs) which gets faint in the middle and demarcates a fairly broad acrosternite (ast). The proximal half of the lateral margin of sternum is emarginated (eml). The pleural membrane connecting the tergum with the sternum also occupies the emargination.

In the male, the eighth sternum, like the eighth tergum is completely membranous leaving, of course, a narrow band of sclerite separating it from the seventh sternum. This band has been taken as anterior limit (margin) of the eighth sternum (amS8) because of the attachment of the ventral longitudinal muscles on it. The eighth sternum (VIIIS) is so telescoped into the seventh sternum that the anterior margin reaches up very close to the antecosta of the seventh sternum. Madden (1944) in P. sexta, Srivastava (1960) in L. orbonalis and Ehrlich (1958) in D. plexippus have shown definite sclerotic eighth sternum. The last worker has shown the posterior portion of this sternum to have modified into bilobed 'pseudovalves'.

The seventh (VIIS) and eighth (VIIIS) sterna of the female undergo modifications because of the presence of bursa copulatrix (bcpx). The anterior margin of the seventh sternum (amS7) is greatly thickened and has lost the acrosternite, while, the posterior margin (pmS7) is deeply invaginated (i). The posterior half of the lateral margins and the entire posterior margin of the sternum have developed marginal inflection (i') giving rise to a distinct irregular shaped pocket (p). More or less, identical invagination of the posterior margin has been recordrd by Klots (1956) in Lepidoptera and Ehrlich (1958) in D. plexippus. They have called it 'sinus vaginalis'. The marginal inflection, at the same time, has not been recorded by these workers. Further, Madden (1944) in P. sexta, Hannemann (1964) in Argynnis paphia L., and Srivastava (1960) in L. orbonalis have neither shown the invagination nor the

inflection of the posterior margin of the seventh sternum. The eighth sternum (VIIIS) is retracted into the seventh sternum and is modified into a narrow sclerotic transverse plate with the middle portion feebly sclerotised. The antero-lateral angle (g) of the sternum is extended to form the anterior apodeme in conjunction with the corresponding angle of the eighth tergum. The anterior and posterior margins are in extensive membranous connections with the posterior margin of the seventh sternum and with the ventral portion of the anterior rim of pseudo-ovipositor, respectively. The anterior margin is convex in the middle and highly sclerotised to come closer to the bursal orifice (bo). The latter is a transverse slit like aperture situated in the inter-sternal membrane between the seventh and the eighth sterm. Embedded in the inter-sternal membrane is a crescent shaped sclerite called bursal plate (bp). Closer association of the latter with the dorsal half of the bursal orifice as compared to its its distance from the eighth sternum shows that the bursal plate works as a source of dorsal suspension for the bursal orifice. This means that the presence of bursal plate in the otherwise extensive inter-sternal membrane can be linked with the presence of bursa copulatrix. It can be compared with the 'lamella postvaginalis' of R. emargana (Klots, 1956) and D. plexippus (Ehrlich, 1958). There is, however, no trace of 'lamella antevaginalis'. However, Klots' (1956) contention weakens the permanent inter-sternal status of the bursal plate, as is evident from his statement, "Typically both of these

arise in the 7th-8th intersegmental cuticula; but the lamella antevaginalis may be so fused with the 7th sternite, and the lamella postvaginalis with the 8th sternite (if present) or tergite, or both, that their distinction is difficult or impossible." Madden (1944) in P. sexta has not recorded any of the two inter-sternal plates. Srivastava (1960) in L. orbonalis shows the copulatory opening on the eighth sternum. This naturally makes bursal orifice segmental instead of inter-segmental. Such interesting observations are compulsorily supported by well stained sagittal sections if these are to be taken seriously.

(ii) The Genital Region of Male (Figs. 104, 105, 106, 110 & 111).

The genital region in the male consists of the ninth segment. This segment undergoes structural modifications to adapt itself to the function of copulation.

Genital tergum.— The ninth tergum (IXT) of the male is a convex plate tapering towards its posterior end, and is completely retracted into the eighth tergum. The anterior margin of the tergum (amT9) is deeply emarginated to shape the tergum into an inverted 'V' shaped plate. The anterior margin is thickened and provides attachment to the extensive inter-tergal membrane. The lateral margins (lmT9) are slightly bent downwards. The posterior margin is greatly reduced having conjunctival connection with the tenth tergum (XT). Due to the shape of the tergum, the antero-lateral angles (aT) are tapering and acute. These extend anteriorly to end in very

close proximity of the antero-lateral angle of the parameres (aP) where also end the dorsal angles of the ninth sternum (aS). These three structures are separated by a very narrow stretch of conjunctiva (mb). The ninth tergum is usually called as 'tegumen' by Lepidopterists (Forbes, 1939; Hannemann, 1954). Klots (1956), however, suggests that the 'tegumen' is chiefly derived from the ninth tergum but its caudal portion may be a contribution of the tenth tergum. Ehrlich (1958) in D. plexippus has shown membranous ninth tergum.

Genital sternum.— The ninth sternum (IXS) of male is reduced to a 'U' shaped sclerotic structure, with its basal portion placed in the lap of the seventh sternum. The posteriorly directed narrow arms (A) in association with the base (B) form an acute angle with the body axis. The oblique nature so attributed to the ninth sternum, puts its anterior (amS9) and posterior (pmS9) margins in dorsal and ventral positions, respectively. The arms flanking the parameres extend further to flank the distal portion of the arms of the ninth tergum. A narrow stretch of membrane intervenes between the apposing surfaces of the structures concerned. The ninth sternum has been termed 'vinculum' by Lepidopterists except Snodgrass (1935) who takes the entire'coxo-sternal arc' as 'venculum'. In U. pulchella, there is no fusion of the sternum with the tergum at any stage and these maintain their separate identities, with the result that no complete ring is formed. Madden (1944) in P. sexta has shown tergal and sternal contiguity which is analogous

to the 'tegumenring' of A.naphia (Hannemann, 1954). The anterior (dorsal) margin of the sternum is produced into a small sclerotic median (mP) and two lateral (lP) bluntly rounded projections. These projections are reflected in such a manner so as to run across and underneath the respective portions of the sternum. These are named as median and lateral projections. The middle portion of the posterior (ventral) margin is convexed so as to come very close to the interparaperal bridge (Pmb). However, the entire posterior margin of the ninth sternum is in membranous connection with the outer surface of the parameres (Pmr). The median projection of the anterior margin should not be cônfused with the 'saccus' of Lepidopterists (Madden, 1944 in P.sexta; Klots, 1956 in Lepidoptera; Ehrlich, 1958 in P.plexippus) because the 'saccus' is always shown to be an apodeme.

(iii) The Genital Region of Female (Figs. 90, 91, 112 & 113).

The Sann hemp moth comes in the suborder Ditrysia, where, generally, the two reproductive openings (gonopore and bursa copulatrix) are separately present. This has affected the normal condition of the genital and post-genital regions in such a way that the eighth segment has been deprived of the privilege of contributing towards the formation of the external genitalia. Likewise, the ninth and tenth segments have lost their separate entity. These segments, as a result of merger, form the apex of the abdomen (pOvp). This means that the true post-genital region (tenth segment) is wanting. Since the apex,

for all practical purposes,helps in egg deposition; therefore, the term pseudo-ovipositor is suggested for it. Other Lepidopterists have called it as 'ovipositor' (Madden, 1944 in P. sexta), 'Endsegment' (Hannemann, 1954 in A. paphia) and 'papillae anales' (Klots, 1956 in Lepidoptera and Ehrlich, 1958 in D. plexippus). Snodgrass (1935) has given a very correct expression of the structures involved and has coined the term 'substitutional ovipositor' for it. It is, therefore, obvious that the fusion of the ninth and tenth segments is inevitable in the absence of a true ovipositor for successful deposition of eggs.

The ninth segment is much reduced and highly modified due to its complete fusion with the tenth segment. The details of the ninth segment will be dealt with the external female genitalia.

(iv) The Post-genital Region (Figs. 104, 106 & 111).

The tenth segment constitutes the post-genital region in both sexes. In male, the tenth tergum (XT) is cylindrical with the apex (m) curved downwards, thereby, assuming the shape of a beak. Basally the cylinder is open, while, apically, it ends blindly. Thus, a distinct basal (anterior) rim of dorsal (rd) and ventral (rv) halves is formed. The dorsal half of the rim is in membranous connection with the posterior margin of the ninth tergum (pmT9), while its ventral half is continuous with the dorsal wall of the membranous anal tube (AT). The present writer assigns it the function

of clasping the abdominal apex of the female during copulation. All Lepidopterists are agreed to call the tenth tergum as unpaired 'uncus', except, Ehrlich (1958) in D.plexippus who attributes paired nature to it. The shape of the 'uncus' however, varies with the insects.

The membranous tenth sternum contributes to the formation of the anal tube (AT) and provides suspension to the latter from the ventral half of the basal (anterior) rim (rv) of the tenth tergum. The anal tube is a small protrubrance carrying the anus at its apex. Its lateral wall close to its apex is semi-sclerotised (SAT) to provide insertion to its retractor muscle. Ventro-laterally, the anal tube is contiguous with the membranous 'diaphragma' (D) and the extensive membranous area,so formed, becomes the posterior end of the abdomen. Non-sclerotic nature of the tenth sternum is also reported by Ehrlich (1958) in D.plexippus. However, Madden (1944) in P.sexta has shown sclerotic 'gnathos' consisting of paired arms which in association with the 'uncus' encloses the anus.

The true post-genital region in the female is totally wanting.

(v) The Pleural Region (Figs. 63, 83, 95, 106 & 112).

The pleural region is represented by a continuous membrane (PlMmb) on either side of thegabdomen with limited sclerotisation in the first segment of both the sexes. In females, the seventh segment also possesses a pleurite, while,

the ninth and tenth segments are completely devoid of it because of the formation of the pseudo-ovipositor. The upper and lower margins of the pleural membranes are connected to the lateral margins of the terga and sterna, respectively.

The pleuron of the first segment is peculiarly modified to form a double walled tympanal hood (h), which covers the delicate tympanic membrane (Tm) to save it from the extremes of atmospheric pressure. The anterior margin of the pleuron of the first segment extends forwards over the posterior arm of the meta-epimeron (pE) to cover the tympanic membrane. On reaching the anterior limit of the latter, it takes up a backwards turn and ends at the posterior margin of the meta-epimeron along a line of flexion (hl). This condition imparts the double walled nature to the hood whose inner wall is feebly sclerotised and also deeply concave. The inner wall (iwh) provides area of insertion to the tympanal muscles coming from the second abdominal tergum. Ventrally, the outer wall bears the first abdominal spiracle. The present writer, therefore, considers the hood as part of the first abdominal pleuron. Similarly, the pleural origin of the hood has been proclaimed by Richards (1933) in Noctuoidea and Treat (1969) in C. devastator. Immediately behind the first abdominal spiracle, the pleuron possesses a narrow vertical pleurite (IPl) which extends upto the lateral tergite of the same segment. Ehrlich (1958) in D. plexippus calls such plate as 'post-spiracular bar'.

The pleuron of the seventh segment of female bears a

heavily sclerotised , more or less, concave oval pleurite (VII Pl) which is confluent with the antero-lateral angle of the segmental tergum. This plate affords a holding ground for the paramere of the male genitalia, during copulation.

In the male, the pleuron of the ninth segment is a fine stretch of membrane connecting the segmental tergum with the sternum. Perhaps, this distinct reduction in the pleuron is caused due to the formation of the extensive diaphragma. Forbes (1939) in S.arctica records a small 'pleurite'in the ninth segment connecting its tergum with the sternum. The same author, in a geometrid moth, has shown complete continuity of the 'pleurite' with the'tegumen'. Further, in Telea polyphemus, he has shown total absence of pleuron which has rendered complete continuity of the segmental tergum with the sternum.

(vi) Musculature of the Abdomen.

The muscles of the abdomen are typically 'inter-tergal','inter-sternal','tergo-sternal' and 'tergo-pleural' muscles (retractors of the tympanal hood). Besides, there are spiracular muscles, muscles of the two diaphragms and inter-tagmatal muscles. The first two types will be dealt with in connection with the respiratory and circulatory systems, respectively. The muscles connected with the male and the female genital complex have been described along with the genitalia.

The first abdominal segment is totally devoid of inter-segmental, as well as, intra-segmental muscles, excepting

one muscle stretched between the second tergum and the first pleuron. This, obviously, means that the inter-segmental muscles coming from the thorax will run across the first abdominal segment to be inserted on the second segment.

Inter-tagmatal muscles.

Levator of the abdomen (Fig. 103; No. 117).— It is a small fan shaped muscle arising on the postero-ventral surface of the posterior arm of meta-epimeron. Ascending obliquely backwards and across the first abdominal sternum, it ends on the antero-lateral angle of the second abdominal sternum. The contraction of this muscle pulls the antero-lateral angle of the second abdominal sternum downwards, thereby, raising the entire abdomen.

Depressor of the abdomen (Figs. 69 & 103; No. 118).— This long thin muscle arises on the posterior face of the lateral process of metathoracic neural plate. Descending backwards, it runs across the first abdominal sternum, to end on the middle of the acrosternite of the second abdominal sternum. This muscle,on contraction, acts antagonistic to the levator of the abdomen. On the basis of the origin and insertion, this muscle can be compared with muscle 'vll' of T. polyphemus.

Inter-tergal muscles.

These muscles normally involve two consecutive terga but should be considered belonging to the tergum which is controlled by them.

Dorsal internal median muscle (Figs. 92, 93, 94, 95, & 98; No. 119).—

It consists of three distinct bundles (a,b,c) connecting the antecosta of a tergum with that of the following tergum. The inner (a) and the outer (c) bundles are parallel, while, the middle one (b) is slightly oblique. In the second segment, the inner (a) and the middle (b) bundles are parallel, while, the lateral one (c) takes up a slightly oblique course. The same muscle consists of six parallel bundles (a-f) in segments four to six. In the first segment, the dorsal internal median muscle is composed of only one bundle stretching between the third thoracic phragma and the middle of the antecosta of the second abdominal tergum. Nüesch (1953), while describing the myology of the thorax of T. polyphemus, has figured a dorsal longitudinal muscle (Fig.2; No. 'dl1') for the first segment of the abdomen. Though no description is available, it may be taken similar to the dorsal internal median muscle of U. pulchella. Treat (1959) in C. devastator has shown only one dorsal longitudinal muscle ('1dl1') putting it in the category of 'dorsal external muscles' of the generalised insect. Taking into consideration his account of this muscle and its subsequent placing in Figs. 6, 10 & 12, it would be more appropriate to consider it identical to the dorsal internal median muscle of the first segment in U. pulchella.

Dorsal internal lateral muscle (Figs. 92, 93, 94, 95 & 98; No. 120).—

This muscle is represented by two parallel bundles (a,b) extending between the antero-lateral angle of a tergum and the

antero-lateral angle of the following tergum. In the second segment, the inner bundle (a) is oblique. In the first segment, this muscle is composed of a single bundle which is stretched between the third thoracic phragma and the antecosta of the second tergum. Also, in the seventh segment, such mono-bundle condition exists.

Dorsal external median muscle (Figs. 92, 96, 97 & 98; No. 121).--

This is shorter than the dorsal internal median muscle, and is composed of three parallel bundles (a,b,c). Its origin is on the posterior one-third of third tergum. Running in latero-medial direction, the bundles end on the anterior margin of the fourth tergum. In the fourth to the sixth segment, the same muscle is represented by only one thick bundle. In the second segment also it has only one bundle which is distinctly thin and long. The mono-bundle condition persists in the seventh segment of the males, but the bundle is conspicuously short and thin. No. dorsal external median muscle is pesent in the first segment with the result that the second tergum is devoid of this muscle.

Dorsal external lateral muscle (Figs. 92, 96, 97 & 99; No. 122).--

It is smaller than the dorsal internal lateral muscle and is made up of four bundles (a,b, c, d) originating in the posterior khalf of the third tergum and running in slightly medio-lateral direction end on the lateral-third of the anterior margin of the following (fourth) tergum. These bundles, for

all practical purposes, constitute the typical 'dorsal external lateral muscle' of insect abdomen. In the second segment, this muscle is represented by two bundles only; the outer among them (b) starts from the anterior half of the submarginal secondary ridge of the segmental tergum. In the seventh segment of the males, this muscle is represented by a single thick and short bundle. In the first segment of both sexes, the dorsal external lateral muscle is completely absent.

All the above muscles are functionally the retractors of the tergal plates of the abdomen, since their contraction increases the overlap between the successive terga.

Reversed inter-tergal muscle (Fig. 103; No. 123).— The reversed inter-tergal muscle is present only between the second and third and between the third and the fourth segments. This fan shaped muscle, arising on the lateral one-fourth of the posterior margin of a tergum runs obliquely in medio-lateral direction, to end on the antero-lateral angle of the following tergum. On contraction, it will act as a protractor muscle of the abdomen.

Normally, the 'reversed inter-tergal muscle' replaces the typical 'dorsal external lateral muscle'. In other words, the former is a modified form of the latter. Such modification is present in higher insects like the honey bee (Snodgrass, 1956) and S. deesaq Alam, (1963). In U. pulchella, there is a distinct deviation from the normal course of modification in the sense

that both the 'dorsal external lateral' and the 'reversed inter-tergal' muscles coexist. So far, no such concurrent appearance of these two muscles has been reported in Insects.

Inter-sternal muscles.

Like the inter-tergal muscles, the inter-sternal muscles also involve two consecutive sterna but should be considered belonging to the sternum which is controlled by them.

Ventral internal median muscle (Figs. 92, 98 & 100; No.124).— It consists of three parallel bundles (a,b,c) stretched between the antecostae of the two successive sterna. The number of bundles becomes five (a-e) in the fourth, fifth and sixth segments with the innermost bundle (a) slightly oblique. In the seventh segment of the males, it is composed of only one short thick bundle.

Ventral internal lateral muscle (Figs. 92, 98 ♀ 100 & 102; No. 125).— This muscle contains two parallel bundles (a,b) extending between the lateral ends of the antecostae of two successive sterna. This muscle is represented by one bundle only in the second segment of both the sexes and in the seventh segment of the males only.

Ventral external median muscle (Figs. 92, 99 & 101; No.126).— This short thick muscle is not split up into bundles. The parallel muscle fibres, starting from the posterior one-third

of a sternum, end on the anterior margin of the following sternum. However, in the fourth to sixth segments, three bundle condition can be attributed to the same muscle.

Ventral external lateral muscle (Figs. 92, 99, 101 & 102; No. 127).— The ventral external lateral muscle is made up of two short bundles (a,b) stretched between the posterior one-third of a sternum and the anterior margin of the following sternum. The three bundle condition of this muscle appears in segments four to six. In the second segment, this muscle is represented by a single thick bundle occupying the lateral one-third of the sternum. The same muscle, in the seventh segment of the males, has also mono-bundle condition, but at the same time it has assumed an oblique course.

Like the inter-tergal muscles, the inter-sternal muscles also become the retractor muscles. Consequently, the inter-tergal and the inter-sternal retracters, combiningly assume the responsibility of retracting the abdomen.

Reversed inter-sternal muscle (Fig. 103; No. 128).— Only one such muscle is present which is short and fan shaped. It starts laterally from the posterior margin of the second sternum and ends on the lateral extremity of the antecosta of the third sternum. The contraction of this muscle helps the reversed inter-tergal muscles in pretracting the abdomen.

Tergo-sternal muscles.

This series of muscles consists of two sets which are similar to the 'Internal' and 'External' sets of lateral muscles of the generalised insects.

External lateral muscle (Figs. 92, 98, 99,& 103; No. 129).— It is not differentiated into bundles but consists of continuous sheet of closely placed fibres running across the pleuron to connect the lateral margins of the segmental terga and sterna. On contraction, it brings the terga and the sterna close to each other. In the absence of a dilator mechanism, the present writer considers that the abdomen expands due to its own elasticity.

Internal lateral muscles (Figs. 92, 98, 102 & 103; Nos. 130 & 131).—

The internal lateral muscles are represented in segmental and inter-segmental forms. The segmental muscles (No. 130) are confined to second and third segments only; while, the inter-segmental muscles (No. 131) are supplied to the third sternum only. In the case of the males, an additional inter-segmental muscle is provided for the eighth sternum. The fibres of the segmental muscle, starting on the posterior one-fourth of the lateral margin of the tergum, descend obliquely to end on the lateral margin of the segmental sternum. The first inter-segmental muscle originates on the side of antecosta of the second tergum. Descending obliquely backwards and crossing the

segmental lateral internal muscle, it ends on the lateral extremity of the antecosta of the third sternum. The course of the second inter-segmental muscle, stretched between the seventh and eighth segments of the males, is identical.

The contraction of the above muscles brings the terga and sterna towards each other, thereby, acting as contractors of the abdomen.

Retractors of the tympanal hood.

These are the modified tergo-pleural muscles which are represented by two pairs of muscles only. These, on the basis of their position, may be called as median and lateral inter-segmental muscles.

Median muscle (Fig. 95; No. 132).— It is a narrow long muscle originating on the middle of the antecosta of the second tergum. Descending obliquely forwards, it ends on the posterior surface of the inner wall of the tympanal hood formed by the first pleuron.

Lateral muscle (Fig. 95; No. 133).— This muscle originates on the antecosta of the second tergum close to the antero-lateral angle. Descending obliquely forwards, it ends on the tympanal hood lateral to the median muscle.

The two pairs of the above muscles appear to work in a coordinated manner. Their contraction is very likely to

pull the tympanal hood backwards and outwards, thereby exposing the tympanal membrane for better touch with the atmosphere. In the absence of an antagonistic muscle, the tympanal hood returns to its normal position by its own elasticity. Treat (1959) in C. devastator two muscles ('1dl2 & 1dl3) with similar course but has not assigned any function to them. His observations regarding origins and insertions of the muscles do not seem to be convincing.

(vii) The External Male Genitalia (Figs. 104, 105, 106, 107, 108, 109, 110, & 111).

A number of workers have studied the external male genitalia of Lepidoptera. Forbes (1939) in Lepidoptera and Hannemann (1954) in A. paphia have laid stress on the myology of the structures. Norris (1932) in Ephestia Kühniella makes a passing reference to the muscles of the genitalia. The derivatives of the ninth and tenth segments have been differently named by various workers. This has resulted in much confusion. However, recently, Snodgrass (1957) by revising interpretations of the male genitalia has put an end to the existing confusion. Zander (1903), Mehta (1933) and Rakshpal (1944) have studied the development of the male genitalia. However, the interpretations given by Mehta (1933) are not in conformity with those of Zander (1903) whose is lately supported by Rakshpal (1944). Mehta (1933) in Pieris brassicae L., and some other forms fixes the responsibility of the development of aedeagus on the 'phallic rudiments' which do not contribute to the formation of the 'valvae'. He contends "It is, therefore, quite clear that the origin of the 'penis' and the 'valvae' lobe takes place not only

independently but also in succession". However, Zander's (1903) view, as reproduced by Snodgrass (1957), shows that in Paranemyx stratiolarius the genital rudiments develop from a single pair of lobes, which, latter on, divide into four lobes. The two median lobes unite to form the aedeagus, whereas, the lateral lobes develop into the 'valvae'. Rakshpak (1944) in Galleria mellonella L., and Acroia grisella L., confirms the views of Zander (1903). Snodgrass (1957) agrees with Zander (1903) and Rakshpal (1944) when he says, "It seems fair to conclude that Mehta failed to observe the lateral displacement of the clasper rudiments, and that the lepidopterous valvae are truly phallic derivatives and are therefore parameres as in Trichoptera. The close association of the parameral bases with the aedeagus in the adult supports this conclusion".

The components of the genitalia of U. pulchella, lying at the abdominal apex, are almost concealed. These are actually placed in the lap of the eighth sternum because of unusual large size of this sternum coupled with drastically reduced condition of the ninth sternum. The latter (IX sternum) consequently becomes the anterior limit of genital components while the eighth sternum has assumed the responsibility of the subgenital plate. The seventh and eighth terga dorsally cover the genitalia. This is due to reduced and telescopic condition of the ninth tergum. The genitalia consist of an unpaired median intromittent apparatus and a pair of parameres lying in association with the diaphragma.

Parameres (Pmr).— There is a pair of well developed parameres limited antero-laterally by the ninth sternum (IXS). The paramere is shaped like a boat. It is placed lateral to the aedeagus (Aed) in such a manner that the bottom of the boat is turned outwards forming the convex lateral surface of the paramere. The two sides of the boat, consequently, become the dorsal (da) and ventral (va) areas of the paramere with their edges forming the dorso-mesal (dmm) and ventro-mesal (vmm) margins. The entire ventral area is plumose. The lateral area (la) is considerably desclerotised. Due to conspicuous change from normal flattened condition to boat shape of paramere, the anterior (am) and posterior margins are drastically reduced. The short posterior margin obliquely connects the ventro-mesal and dorso-mesal margins. This is internally represented by a broad marginal inflection (r). The conspicuously attenuated anterior margin is drawn upwards to fuse with its counterpart of the other paramere and, thereby, forms the interparameral bridge (Pmb), more or less, similar to the 'interparameral bridge' of Bombyx mori L., (Snodgrass, 1957). The paramere of Lepidoptera has been called the 'valve' by Lepidopterists (Forbes, 1939; Sibatani et. al., 1964; Hannemann, 1964; Klots, 1956; Ehrlich, 1958). Madden (1944), however, calls it as 'harpe'. A complex articulation of the 'costa' with the 'pleurite' and the 'vinculum' is reported by Forbes (1939) in E. arctica. Madden (1944) and Ehrlich (1958) show it to articulate with the 'vinculum'. The dorsal area of the paramere of E. philchella is comparable with the 'costa' of Sibatani et. al., (1964).

The 'sacculus' of Lepidopterists is nothing but one-half of the interparamer-l bridge of U.pulchella. The lateral area of the paramere of U.pulchella all along its posterior margin is continued posteriorly in the form of a broad blunt flexible ventral process (vpr) which has membranous connection with the posterior end of the ventral area. The ventral portion (v) of this process is well sclerotised and plumose, whereas, the dorsal portion (d) is semi-sclerotised and extends upto the parameral lobe. Likewise, the dorsal area is produced into a stumpy non-articulated plumose dorsal process (dpr). The ventral and the dorsal processes of the paramere of U.pulchella can be taken as the 'valvula' and 'ampulla' of Sibatani et al (1954).

The posterior margin in association with the dorso-mesal margin develops a small sclerotic parameral cone (Pc). The lumen of this cone is in continuation with the lumen of the paramere and provides a clear passage for the adductor of parameral lobe. Flanking the cone, as well as, the posterior margin of the paramere is an elongated sclerotic structure which has been labelled as the parameral lobe (Pmrl). The inner surface of the latter, somewhere in its middle, possesses a 'V' shaped ridge (v) which faces the free end of the parameral cone. Further, the ridge is also in membranous suspension from the parameral cone and provides the area for the insertion of the adductor muscle. The parameral lobe is the only mobile structure of the paramere provided with a muscle and is, therefore,

easily comparable with the 'clasper' of S. arctica and 'harpe' of Lepidoptera described by Forbes (1939) and Sibatani et al (1954) respectively.

The dorsal area of the paramere, slightly anterior to the dorsal process, is produced mesally into a curved sclerotic structure which is the 'transtilla' of Lepidopterists. The curved nature of the transtilla (Tr) and its mesally directed course makes it to move towards the aedeagus, thereby, lies between the latter and the paramere. The broad apical portion of the transtilla is incompletely twisted with the result that its apical margin (Tra), which is concave, gets the opportunity of abutting against the dorso-lateral surface of the distal portion of the aedeagus. It is here that the aedeagus is suspended from the transtillae by fine conjunctiva. Forbes (1939) finds the 'transtilla' to articulate with the 'ental extension of the valve'. Similarly, Madden (1944) shows the articulation of the 'transtilla' with the 'harpe'. Klots (1956) is doubtful about its origin. He considers it to be either a sclerotisation in the 'diaphragma' or to be a derivative of the mesal extension of the 'valve'.

Basal plate (BP).— It is a subtriangular sclerotic plate situated in between the ventral areas of the parameres but posterior to the interparameral bridge. The basal plate ventrally supports the aedeagus. The base of the triangle forming the anterior margin is deeply concave with its middle portion (x) slightly lower in level with the interparameral

bridge. Likewise, the remaining portion (lateral third) of the anterior margin (y) acquire a higher level as compared with the interparameral bridge. The sides of the triangle are convex, and the vertex is broadly rounded. The basal plate is weakly sclerotised along its midlongitudinal line (f) along which the two halves of the triangle may undergo flexion. The anterior and lateral margins of the basal plate are in membranous connection with the interparameral bridge and the ventro-mesal margins of the ventral areas of the parameres, respectively. The vertex of the plate is continuous with the diaphragma.

Forbes (1939) in S. arctica and Klots (1956) in Crambus subaequalis Zeller, Crephasia and Agonopterys fulva W., have shown a sclerotic piece like that of U. pulchella and name it as the 'juxta'. Madden (1944) in P. sexta has described the 'juxta' as ventral sclerotisation of the 'anellus', whereas, Ehrlich (1958) in D. plexippus considers 'juxta' as sclerotisation of the 'diaphragma' underneath the aedeagus. Snodgrass (1957) in Carpocapsa pomonella L., records a basal plate like that of U. pulchella which he considers to have prolonged backwards as the 'fulcrum' whose concave apex receives the base of the aedeagus. Perhaps, Snodgrass (1957) is correct when he says, "The arm of the basal plate that supports the aedeagal pouch (fig. 11 B, ful) is the juxta of lepidopterists, but the word "juxta" is an adverb and not a noun in Latin. The arm apparently serves as a prop for the movement of the aedeagus, and is here

termed the aedeagal fulcrum." The present writer, however, suggests that the 'juxta' should not be taken as a part of the 'anellus' as it would automatically become a derivative of the aedeagus. It is, further, suggested that the basal plate of U. pulchella is equivalent to the 'basal plate' minus the 'fulcrum' of C. pomonella (Snodgrass, 1957), as well as, to the 'juxta' of C. subaequalis, Cnephasia and A. fulva (Klots, 1956). Consequently, it is concluded that the 'juxta' so defined may be synonymised with the basal plate.

Aedeagus (Aed).— The aedeagus is a hollow slender tube closed at its inner end lying in the venter of sixth to ninth segments. Its proximal one-fourth (AedAp) is highly sclerotised and provides insertion to the protractor of the aedeagus. Similar unpaired component of the aedeagus has been named as 'Blindsack' and 'coecum' in A. paphia (Hannemann, 1954) and C. subaequalis (Klots, 1956) respectively. Alam (1953) in S. deesae has shown such paired structures and named them 'aedeagal apodeme'. The present writer selects the term 'aedeagal apodeme' for it. The lateral and ventral walls of the aedeagus are incompletely sclerotised while the dorsal wall is totally membranous. The left wall of the aedeagus, in the vicinity of the phallotreme, is heavily sclerotised with posteriorly directed spines (sp). Somewhere in the middle, the aedeagus is encircled by the membranous diaphragma which gives out membranous folded suspensorium (fs) to provide suspension to the aedeagus. The suspensorium is homologous to the 'anellus' of Lepidoptera as defined by Klots (1956). The folded nature of

the suspensorium allows the forward and backward movements of the aedeagus. Dorsally, the ejaculatory duct (Dej) pierces through the wall of the aedeagus and coils there before opening into the dorsal wall of the free end of the endophallus. The opening of the ejaculatory duct into the latter marks the true gonopore. The distal tip of the aedeagus looks like an oblique aperture (Phtr) and is actually the site of the invagination of the endophallus. The latter (Enph) is an eversible membranous sac, the inner surface of whose walls is clothed with minute spines (S). Somewhere in the middle of the undersurface of the dorsal wall of the endophallus are two prominent triangular sclerotic plates (dSclp). Likewise, the ventral wall possesses two sclerotic plates (vSclp) near the true gonopore; one of them is triangular in shape, while, the other is semicircular and toothed. During copulation, when the endophallus is everted out, these plates become external to grip the bursa copulatrix. Klots (1956) has shown the endophallus a synonym of 'vesica'. The ventral wall of the endophallus is secondarily modified along a narrow strip into a semi-sclerotic ventral plate (vp) which is extended anteriorly into the aedeagus to receive the retractor of the endophallus.

Musculature of the Genitalia.

The entire set of muscles in control of the activities of the external male genitalia is, no doubt, breakable into two sets of muscles which are generally regarded as extrinsic and intrinsic muscles of the genitalia in insects. In U. pulchella,

two sets of extrinsic muscles have been discovered, which, on the basis of their comparative responsibility for the activities of the genitalia are named as 'direct' and 'indirect' extrinsic muscles. The series of 'direct' extrinsic muscles consists of such muscles which originate on the ninth segment to insert on any component of the genitalia. The 'indirect' set of extrinsics is composed of the muscles originating on the eighth segment to end on the ninth segment, as well as, the muscles with origin on the ninth tergum and insertion on the tenth segment. The present writer regards these muscles as genital muscles because of the very close association of the ninth and tenth segments with the genitalia. The intrinsic muscles in U. pulchella are those which, originating on any component of the genitalia, also end on some other component of the genitalia. The extrinsic set of muscles of S. arctica (Forbes, 1939) may be taken asimilar to the 'indirect' extrinsic muscles of U. pulchella. Forbes (1939) has included the, hitherto, direct extrinsic muscles among the intrinsic muscles of the genitalia. Other workers like Hannemann (1964) in A. paphia and Ehrlich and Davidson (1961) in D. plexippus are silent on such categorisation of the muscles of the genitalia.

Direct extrinsic muscles of the genitalia.

Adductor of transtilla (Figs. 106, & 111; No. 134).— This is a short thick muscle which arises dorsally on the lateral projection of the arm of ninth sternum. Its, more or less, parallel fibres ascend obliquely backwards to end on the posterior margin of transtilla. Its contraction pulls the transtilla

forwards and outwards. This pull, when transmitted to the twisted apical portion of the transtilla, makes it move towards the aedeagus, which, consequently, is arrested by its concave margin.

Protractor of the aedeagus (Fig. 111; No. 135).— This thick muscle originates on the anterior margin of the ninth sternum between the lateral and median projections. Running anteriorly, the fibres end on the latero-ventral surface of the aedeagal apodeme, almost completely surrounding it. On contraction, the muscle pushes out the aedeagus to assist its entry into the bursa copulatrix. It is similar in function to muscle 'pm' of E. kühniella (Norris, 1932), to the 'protractor of aedeagus' of S. arctica (Forbes, 1939) and to 'M. tegmino-aedoeagalis' of A. paphia (Hannemann, 1954).

Retractor of the aedeagus (Fig. 111; No. 136).— It is antagonistic to the protractor of the aedeagus but is comparatively more thick and stout. It arises on the basal portion of the ninth sternum and, ascending posteriorly, crosses the protractor of the aedeagus to get inserted on the middle of the ventral wall of aedeagus; some fibres are also inserted on its lateral wall. The contraction of this muscle brings the aedeagus back to its normal position after the mating is over. It seems similar to muscle 'rml' of E. kühniella (Norris, 1932), to the 'retractor of aedeagus' of S. arctica (Forbes, 1939) and to 'M. vinculo-aedoeagalis' of A. paphia (Hannemann, 1954).

Indirect extrinsic muscles of the genitalia.

First levator of the genitalia (Figs. 98 & 110; No. 137).— It is a long thin muscle which arises on the middle of the anterior margin of eighth tergum. Diverging laterally, the muscle descends to get inserted on the lateral projection of the ninth sternum. It is similar to muscle 'T2' of S. arctica. Hannemann (1954) in A. paphia shows two such pairs of muscles ('T2' and 'T3') and takes them as retractors of the genitalia. The course of this muscle in H. pulchella throws doubt on the validity of the function assigned to it by Hannemann (1954).

Second levator of the genitalia (Figs. 98 & 110; No. 138).— This short thick muscle arises on the anterior margin of the eighth tergum. The muscle descends obliquely to end on the lateral projection of the ninth sternum, ventral to the insertion of the first levator of the genitalia. No such muscle is reported by Forbes (1939) in S. arctica and Hannemann (1954) in A. paphia.

The contraction of the above two levator muscles raises the genitalia upwards.

First retractor of the genitalia (Figs. 98 & 111; No. 139).— This long and thin muscle, arising laterally on the anterior margin of the eighth tergum, converges backwards to end on the middle of the anterior margin of the ninth tergum. A similar muscle 'T1' is recorded by Forbes (1939) in S. arctica. Hannemann (1954) assigns a similar function to such muscle ('T1') in A. paphia.

Second retractor of the genitalia (Figs. 98 & 110; No. 140).— It is a thick muscle whose origin lies on the anterior margin of the eighth sternum. The fibres of this muscle ascend obliquely backwards to be inserted on the lateral projection of the ninth sternum ventral to the insertion of the second levator of the genitalia. It is comparable with muscle 'S3' of S. arctica (Forbes, 1939). Hannemann (1954) in A. paphia regards a similar muscle ('S3') as retractor of the genitalia.

Third retractor of the genitalia (Figs. 98 & 110; No. 141).— This short thick muscle arises laterally on the anterior margin of the eighth sternum ventral to the origin of the second retractor of the genitalia. Running mesally directed, it gets inserted on the median projection of the ninth sternum. It is similar to muscle 'S1' of S. arctica (Forbes, 1939). Hannemann (1954) in A. paphia records a similar muscle ('S2') with a similar function.

The above three retractors of the genitalia keep the genitalia in normal position during copulation. Since the entire male genitalia lie as a unit in a membranous covering (eighth segment) there is every likelihood of this unit being detached from the body as a result of activities of the female based on uncalled for disturbance during copulation. The three retractors of the genitalia provide protection to the male genitalia from damage and also get them back to the normal position after copulation.

Depressor of the tenth tergum (Fig. 111; No. 142).— This thick muscle originates on the emarginated anterior margin of the ninth tergum. Tapering posteriorly, it gets inserted on the ventral half of the anterior rim of the tenth tergum. The contraction of this muscle depresses the tenth tergum, which, in turn, holds the dorsum of the seventh segment of the female during copulation. It is similar to the 'depressor of uncus' of S. arctica (Forbes, 1939) and to 'Musculus unco-tegminalis' of A. paphia (Hannemann, 1964).

Retractor of the anal tube (Fig. 111; No. 143).— This long thin muscle, composed of parallel fibres, arises on the antero-lateral angle of the ninth tergum and descending obliquely backwards ends on the inner surface of the semi-sclerotin lateral wall of the anal tube. The contraction of this muscle retracts the anal tube but its dorso-ventral course suggests partial lifting up of the anal tube. It is similar to the 'retractor of anal tube' of S. arctica (Forbes, 1939).

Intrinsic muscles of the genitalia.

Adductor of the parameral lobe (Figs. 107 & 111; No. 144).— This thick muscle originates on the entire ventro-mesal and anterior margins of the paramere. The fibres converge to a very narrow bundle which, ascending obliquely, passes through the parameral cone to be inserted on the 'V' shaped ridge of the parameral lobe. On contraction, the muscle bends the parameral lobe inwards, which, in turn, pulls along it the ventral

process of the paramere, as well. As a sequence to it, the parameres grasp the apical portion of the female abdomen at the time of copulation. This muscle is comparable with the 'flexor of clasper' of S. arctica (Forbes, 1939) and 'M. sacculo-ampullaris' of A. paphia (Hannemann, 1954).

Indirect levator of the aedeagus (Fig. 108; No. 145).— The indirect levator of the aedeagus takes its origin on the lateral surface of the interparameral bridge and ascending obliquely gets inserted, by a broad base, on the lateral one-third of the anterior margin of the basal plate. On contraction, it pulls down the anterior margin of the basal plate with the result that its distal half is raised upwards as if working on a fulcrum. The basal plate, by virtue of its being distinctly ventral to the aedeagus, obviously, lifts the latter. This should not be confused with the 'flexor of the valve' of S. arctica (Forbes, 1939) since the course of action of the two muscles is distinctly different. This muscle, is, for the first time, reported in Lepidoptera.

Indirect depressor of the aedeagus (Figs. 108 & 111; No. 146).— It is a long thin unpaired muscle which arises on the middle of the interparameral bridge mesal to the indirect levator of the aedeagus. Running backwards and downwards, its fibres are inserted on the middle-third of the anterior margin of the basal plate. Since the origin of this muscle lies at a higher level than the insertion, its contraction raises the

anterior margin of the basal plate. The distal half of the basal plate, working like a lever, is, consequently, depressed and along with it depresses the aedeagus as well , bringing it back to its normal position . Thus, the muscle functionally becomes antagonistic to the indirect levator of the aedeagus. This muscle has not, so far, been reported in Lepidoptera.

Retractor of the endophallus (Fig. 109; No. 147).— This thick muscle is located within the aedeagal apodeme. Its fibres originate by a broad base on the entire inner surface of the blind end of the aedeagal apodeme. Running posteriorly, the fibres slightly converge to end on the ventral semi-sclerotic plate of the endophallus. The contraction of this muscle enables the everted endophallus to retract to its normal position inside the aedeagus at the end of copulation. Norris (1932) in E. kühniella and Forbes (1939) in S. arctica have not included this muscle in the description of the musculature of genitalia in their respective insects. Of course, a, more or less, similar muscle has been reported in A. pacphia by Hannemann (1954) who calls it 'Retraktor der Vesica'.

Working of the Male Genitalia.

Prior to copulation, the male moth brings the distal end of its abdomen close to the corresponding abdominal apex of the female. As soon as the male genitalia touch the female, the latter raises its abdominal apex so that the male brings the genitalia more close to the bursal orifice. The contraction

of the indirect extrinsic levators of the genitalia puts the male genitalia at the level of the bursal orifice and also enables the parameres to flank the seventh abdominal segment of the female moth. This is followed by the contraction of the adductor muscles of the parameral lobes with the result that the latter firmly grasp the seventh abdominal segment of the female. Simultaneously, the beak shaped tenth tergum , under contraction of its depressor muscle, holds the dorsum of the seventh segment of the female. When complete gripping of the female by the male is attained, the direct extrinsic adductor muscles of the transtillae contract enabling the latter to hold the aedeagus. The latter is then lifted by the contraction of its intrinsic indirect levators. The direct extrinsic protractors of the aedeagus come into action and the aedeagus is, consequently, fully protruded out to enter into the proximal half of the bursa copulatrix. At this stage, the endophallus is everted out and the male gonopore opens into the bursa copulatrix.

When the copulation is over, the intrinsic retractor of the endophallus contracts to bring back the endophallus into the aedeagus. This is followed by simultaneous relaxation of the direct extrinsic protractors of the aedeagus and the contraction of the direct extrinsic retractors of the aedeagus to enable the aedeagus to withdraw from the bursa copulatrix. The direct extrinsic adductors of the transtillae undergo relaxation, with the result that the transtillae lose grip on

the aedeagus. The latter is then brought back to its normal position due to the simultaneous relaxation and contraction of the intrinsic indirect levators and depressor of the aedeagus. The relaxation of the intrinsic adductors of the parameral lobes and the indirect extrinsic depressors of the tenth tergum, make the paramoral lobe and the tenth tergum lose grip on the female abdomen. Lastly, the indirect extrinsic retractors of the genitalia contract, thereby, enabling the genital complex to regain its normal telescopic condition.

(viii) The External Female Genitalia (Figs. 112, 113 & 114).

As in most Lepidoptera, a typical ovipositor is lacking in U. pulchella. The abdominal apex (fused ninth and tenth segments) is so modified as to take up the duty of egg deposition and has accordingly been named as pseudo-ovipositor (pOvp). The fact that the pseudo-ovipositor represents the combined ninth and tenth segments is based on the presence of ten distinct segments in the larva of U. pulchella. The pseudo-ovipositor is cone shaped. It is mostly membranous with a distinct lateral sclerotic plate (lp) in each lateral wall, which is studded with long setae. The anterior rim of pseudo-ovipositor is in membranous connection with the eighth segment, while, its posterior surface is broadly invaginated to receive the anus (An) and the gonopore with the anal orifice dorsally placed. The middle of the anterior margin of the lateral plate is produced into long sclerotised posterior apodeme (pap). Its base is broad and bulb shaped (b).

The posterior apodeme is longer than the anterior apodeme (aap) and provides attachment to the muscles involved in the protrusion and retraction of the pseudo-ovipositor. The inter-tergal membrane between the eighth segment and the pseudo-ovipositor bears the opening of a long narrow highly convoluted tubular attractant gland (SG).

The present writer thinks that the ninth and the tenth segments have lost the normal linear arrangement of abdominal segments. These have, during metamorphosis, moved upwards to assume a vertical relation with the body axis. Such shifting of the body structures along ninety degree has put the combined venter of the ninth and tenth segments relatively posterior to the remaining portion of these segments which is pushed anteriorly. This orientation can be justified from the fact that the openings of the digestive (An) and reproductive (opr) systems are borne by the posterior surface of the pseudo-ovipositor.

Musculature of the Genitalia.

The musculature of the female external genitalia comprises of the extrinsic muscles only. Like that of the male genitalia, the entire set of muscles controlling the activities of the female external genitalia (pseudo-ovipositor) is divisible into 'direct' and 'indirect' series of muscles. The set of 'direct' extrinsic muscles consists of such muscles which originate on the seventh and eighth segments to be inserted on the pseudo-ovipositor; whereas, the 'indirect' set

of muscles is composed of the muscles originating on the seventh segment to be inserted on the eighth segment. The present writer regards these muscles as genital muscles because of the very close association of the eighth segment with the pseudo-ovipositor. Since the genitalia are completely telescoped into the eighth segment, any activity of the latter will have a telling effect on the genitalia. Such type of categorisation of the genitalia muscles is recorded for the first time in Lepidoptera.

Direct extrinsic muscles of the genitalia.

First protractor of the pseudo-ovipositor (Fig. 114, No.148).. This muscle is long and slender. Its fibres arise on the posterior margin of the eighth tergum, a little lateral to its middle. Taking up an anteriorly directed course, the fibres converge on the dorsal surface of the apex of posterior apodeme. On contraction, the muscle pulls the posterior apodeme backwards, thereby, protracting the pseudo-ovipositor. It can be compared with muscle 'g' of E.kühniella (Norris, 1932). No such muscle is, however, shown to be present in A.panhia (Hannemann, 1964).

Second protractor of the pseudo-ovipositor (Fig. 114; No.149). It is the longest of all the muscles that control the working of the pseudo-ovipositor. The muscle originates close to the middle of the anterior margin of the eighth sternum and ascending obliquely forwards passes mesal to the anterior apodeme to get inserted on the ventral surface of the posterior

apodeme. On contraction, it pulls the posterior apodeme backwards with the result that the pseudo-ovipositor is protruded out. Besides this, the insertion of the muscle being at a level much higher than its origin suggests the probability of the pseudo-ovipositor being raised up. Primarily, it is a protractor muscle of the pseudo-ovipositor, but at the same time may be held responsible for tilting up the pseudo-ovipositor. As such, it can be considered to have combined the responsibility of 'M.sterno-postapophysalis maior' and 'M.sterno-postapophysalis minor' of A.paphia (Hannemann, 1964).

Depressor of the pseudo-ovipositor (Fig. 114; No. 150).— This muscle is cylinderical and arises by a narrow base on the ventral surface of the anterior apodeme. Descending obliquely backwards, the muscle ends ventrally on the anterior rim of the pseudo-ovipositor. The muscle, on contraction, pulls the anterior rim of the pseudo-ovipositor forwards and upwards. This, consequently, results in the tilting of the pseudo-ovipositor which is necessary to press the egg on the substratum at the time of egg laying. It is similar to 'M.tergosternalis (intersegmentalis 8-9 + 10)' of A.paphia (Hannemann, 1964).

First retractor of the pseudo-ovipositor (Fig.114; No.151).— This muscle, consisting of two bundles, originates on the thickened anterior margin of the seventh tergum. The fibres,

in a convergent manner, take up antero-posterior direction to end on the apex of the posterior apodeme. The contraction of this muscle will bring back the protruded pseudo-ovipositor to its normal position. It is similar to muscle 'e' of E.kühniella (Norris, 1932). Hannemann (1964) has not recorded this muscle in A.paphia.

Second retractor of the pseudo-ovipositor (Fig. 114; No.152).. It is a comparatively broad muscle which arises by a narrow base on the apex of the anterior apodeme. Running posteriorly, the muscle ends broadly on the bulbous base of the posterior apodeme. The contraction of this muscle pulls the protruded pseudo-ovipositor anteriorly, thereby, restoring it to its normal position. It is comparable with muscle 'h' of E.kühniella (Norris, 1932) and 'M.interapophysalis' of A.paphia (Hannemann, 1964).

Indirect extrinsic muscles of the genitalia.

Protractor of the genitalia (Fig. 114; No. 153).— It is a long thin muscle arising laterally on the posterior margin of the seventh tergum. The fibres take up an anteriorly directed course to end dorsally on the apical portion of the anterior apodeme. The contraction of this muscle pulls the anterior apodeme backwards with the result that the eighth segment gets protracted taking with it the pseudo-ovipositor. This muscle is reported, for the first time, in Lepidoptera.

Retractor of the genitalia (Fig. 114; No. 154).— This long muscle takes its origin laterally on the anterior margin of the seventh tergum lateral to the origin of the first retractor of the pseudo-ovipositor. Running backwards, the muscle gets inserted on the apex of the anterior apodeme. It is comparable with muscle 'c' of E. kühniella (Norris, 1932). Hannemann (1954) in A. paphia has shown two such muscles ('X2' and 'X3') which are identical in origin, insertion and function to the retractor of the genitalia in U. pulchella. It appears to the present writer that the two muscles of A. paphia are merely two bundles of a single muscle.

Secondary retractor of the genitalia (Fig. 114; No. 155).— It is a short thick muscle which originates laterally on the posterior one-fourth of the seventh tergum. This muscle, with parallel fibres, runs obliquely backwards to end laterally on the anterior margin of the eighth tergum. It is similar to muscle 'X1' of A. paphia (Hannemann, 1954). Norris (1932) in E. kühniella has not recorded this muscle.

On contraction, the two retractor muscles bring the eighth segment back to its normal telescopic condition bringing with it the pseudo-ovipositor. The secondary retractor muscle apparently appears to retract the eighth tergum, but the rigid connection of the eighth tergum with the segmental sternum along the anterior apodeme makes it effective for the entire eighth segment. This, obviously, helps the retractor of

the genitalia in retracting the eighth segment. Norris (1932) in E.kühniella has not dealt with the functions of the individual muscles but at the end of the description of the muscles, remarks "This extensive muscle complex serves for the retraction and protrusion of the ovipositor."

Dilator of the vagina (Fig. 114; No. 156).— It is a small fan shaped muscle arising by a narrow base on the apex of the anterior apodeme. Descending obliquely backwards, the muscle gets inserted on the lateral wall of the vagina posterior to the opening of the spermathecal duct into it. On contraction, the muscle dilates the vagina in order to facilitate the passage of eggs during oviposition. Norris (1932) in P.interpunctella labells a similar muscle as the 'Retractor muscle of the oviduct'.

Dilator of the bursal duct (Fig. 114; No. 157).— The dilator of the bursal duct is a thick muscle, with parallel fibres, arising on the posterior half of the lateral margin of the seventh sternum. These fibres descend obliquely to get inserted in the dorsal wall of the posterior half of bursal duct. The contraction of this muscle dilates the bursal duct, thereby, assisting in the entry of the aedeagus. It is comparable with 'M.sterno-bursalis lateralis' of A.paphia (Hannemann, 1954).

Working of the Female Genitalia.

In U.pulchella, the principal function of the female genitalia is the deposition of eggs. When the female moth is

ready for oviposition, it moves to and fro for selecting a suitable site to deposit the eggs. The indirect protractors of the genitalia contract to protrude out the eighth segment which carries the pseudo-ovipositor with it. This is followed by the contraction of the direct protractors of the pseudo-ovipositor so that the pseudo-ovipositor is protruded out from the lap of the eighth segment. In the wake of this protrusion, the eggs are deposited. To ensure the fixing of the eggs on the substratum, the pseudo-ovipositor presses them by its tip under the action of its direct depressors. After the deposition of one egg, the depresor of the pseudo-ovipositor relaxes which allows the pseudo-ovipositor to leave the substratum. The female, with raised pseudo-ovipositor, moves a little forward to repeat the act of egg laying. When the complete set of eggs is deposited, the pseudo-ovipositor is raised as a result of the relaxation of its depressor. This is followed by the simultaneous relaxation of the direct protractor muscles and contraction of the direct retractor muscles of the pseudo-ovipositor to bring the pseudo-ovipositor back to its normal telescopic condition inside the eighth segment. Similarly, the relaxation of the indirect protractors and the contraction of the indirect retractors of the genitalia enable the eighth segment to resume its normal position.

4. THE INTERNAL ANATOMY.

(1) Digestive System (Figs. 25,& 115).

The alimentary canal of U.pulchella is, more or less, a straight tube extending between the mouth (tm) and the anus (An). It is morphologically divisible into three main regions: the stomodaeum , the mesenteron and the proctodaeum. Their external distinction is based on size and shape. The true mouth is located high up in the head preceded by the sucking pump (SP) and the proboscis. The sucking pump is purely cibarial in origin.

Stomodaeum.— The stomodaeum consists of the cephalic stomodaeum i.e., the pharynx (Phy) lying in the head capsule followed by the oesophegus (Oe), crop (Cr) and proventriculus (Prvent). The narrow short tubular pharynx is not much different from the oesophagus. However, for descriptive purposes, the present writer considers the portion of the stomodaeum lying within the cranium as the pharynx, which continues posteriorly into the oesophagus.

Oesophagus (Figs. 115 & 116).— The pharynx leads into a long narrow cylinderical oesophagus (Oe) which runs from the foramen magnum to the posterior region of the first abdominal segment, passing on its way across the thorax. At its posterior end, the oesophagus develops a dorsal diverticulum called 'crop' just before communicating with the proventriculus. The oesophagus is provided with both circular (cmcl) and

longitudinal (lmcl) muscle layers. The former is stouter and lies external to the latter. The longitudinal muscle layer is represented by distally placed six bundles of fibres. The epithelium (aEpth) of the oesophagus is, more or less, of syncytial nature and contains fine granulation (gn). The nuclei (nu) are small but distinct and are interspersed under no definite plan. A distinct intima (In) lines the internal surface of the epithelial layer. The entire oesophageal epithelium is thrown into longitudinal folds hanging free into the lumen. These folds are almost uniform throughout the length of the oesophagus, thus differing from the condition in S. deesae (Alam, 1953) where these folds get deeper and deeper in antero-posterior direction. Alam's (1953) suggestion of the presence of 'oesophageal extension in the crop' is, no doubt, a distinct addition to the morphology of the digestive tract of non-regurgitatory insects. Its absence in U. pulchella may be attributed to the fact that the oesophagus and the crop relationship is not so perfect as in S. deesae. Henson (1931) records a syncytial oesophageal epithelium in the larva of Vanessa urticae. Grell (1938) in Panorpa communis L., hasalso reported syncytial type of oesophageal epithelium. However, Pyle (1940) in Callosamia promethea has recorded flat celled epithelium. Mortimer (1965) in Hemialus lupulinus L., and H. humuli records syncytial and non-muscular nature of the oesophagus.

Crop (Figs. 115, 117 & 118).— The crop is large and sac like and occupies the upper portion of the first three abdominal segments when fully distanded with food. Under unfed condition, it is collapsed tp a small sac with numerous folds

in it and confined to the first abdominal segment. These folds enable the crop to undergo great distention for storing of the food. Histologically, the crop does not differ from the oesophagus. The epithelial folds are much more than those of the oesophageal epithelium. The longitudinal muscle layer (lmcl) is represented by numerous bundles. This modification is required to expel the food back into the oesophagus for onward movement to the proventriculus. In certain insects, the inflating of the crop with air facilitates breaking of pupal case. Pyle (1940) in Lepidoptera upholds this view, and records the crop full of air in a newly emerged female of C. promethea. The present writer feels inclined to attribute the same function to the crop of U. pulchella at the time of emergence. However, it is, later on, used permanently as a food reservoir.

Proventriculus (Figs. 115 & 119).— The proventriculus (Prvent) of U. pulchella is a short tubular portion of the stomodaeum communicating with the crop and the oesophagus at one end and with the mesenteron at the other. Since the moth feeds on liquids only, the proventriculus is not developed into a crushing centre and is regarded as a passage for the descent of food. Akbar (1958) in L. varicornis attributes the absence of proventricular armature to the behaviour of the bug to feed on plant juices. Histologically, it is identical to the oesophagus. Recently, Mortimer (1965) has called the proventriculus of Plusia gamma L., as the 'intermediate chamber'. The latter is, however, shown to be absent in Arctia caja L.

The stomodaeal valve (svlv) is formed by the posterior tip of the proventriculus, which hangs as a narrow tube to a short distance, into the lumen of the ventriculus. The epithelial layer of the valve is double walled. The inner wall (facing the lumen of the valve) is a prolongation of the proventricular syncytial epithelium while the outer wall is formed by the ventricular epithelium. The double walled nature of the valve gets further support from the fact that the inner wall is lined by a cuticular intima (In), while, the outer wall lacks in it. The valve is devoid of muscles excepting its base, where, the circular and longitudinal muscle layers of the proventriculus, as well as, the extension of the circular muscle layer of the mid-gut can be recorded. The stomodaeal valve functions as a free passage for the descent of food from the stomodaeum to the mesenteron. Perhaps, it also prevents the food contents from being pushed back by ordinary movements of the ventriculus. Pyle (1940) in S. promethea shows a well developed double layered valve and calls it the 'oesophageal valve'. In insects, where a proventriculus is well developed, e.g., S. obesana (Alam, 1953) and the honey bee (Snodgrass, 1956), the stomodaeal valve is strongly developed.

Mesenteron (Figs. 115, 119, 120, 121, 122 & 123).— The mesenteron (ventriculus), like a convoluted tube, runs from the anterior region of the second abdominal segment to the

fifth abdominal segment. Externally, the mesenteron (Ment) has an uneven surface due to the presence of circular wrinkles. It is, although, closely associated with long malpighian tubules (Mal).

The histology of the ventriculus is different from that of the stomodaeum. It is externally covered over by a longitudinal muscle layer (lmcl); next to it comes the circular muscle layer (cmcl). The epithelium (Epth), which is internally produced into several villi, is composed of tall columnar cells suspended from a distinct basement membrane (BMB). The cells are thickly granulated (gn) and contain a conspicuous oval nucleus (nu) in the basal half. The nuclei are laden with distinct chromatin granules (gn). The internal border (sb) of the epithelial cells is striated by numerous fine lines lying perpendicular to it. Pyle (1940) in C. promethea does not record the striated border. Akbar (1958) in L. varicornis shows the striated border similar to that of U. pulchella.

Peritrophic membrane.— The peritrophic membrane in U. pulchella is never formed as in certain other Lepidoptera (vide Waterhouse, 1963 and Mortimer, 1965). It has been reported as absent in L. varicornis (Akbar, 1958) as well, which, also feeds on liquid food. It has generally been thought that the peritrophic membrane serves to protect the mid-gut epithelium from being damaged by the hard particles of food. However, there are records of the absence of peritrophic membrane in insects

(Carabidae and Dytiscidae) which subsist on hard particles (vide Wigglesworth, 1930). In an interesting contribution Waterhouse (1953) has shown the presence of the peritrophic membrane in the adults of several species of Lepidoptera and Diptera. However, he does not show its occurrence in the members of the family Arctiidae examined by him. Consequently, the present writer feels inclined in upholding Waterhouse's suggestion by considering the absence of the peritrophic membrane as a 'character of assistance to the taxonomists' for the family Arctiidae. Further, it would, perhaps, be not very incorrect to suggest here that the food habits of the insects cannot, in a generalised manner, be correlated with the absence or presence of the peritrophic membrane in insects.

Regenerative cells (rg).-- Besides the tall columnar cells of the ventricular epithelium, there are also present a large number of small regenerative cells. These are normally arranged into nidi (ni) of ten to twelve cells at the base of the villi. Further, the inter-villular portions of the epithelium also contain regenerative cells in a scatterd manner. The cytoplasm of the regenerative cells is fairly granulated with distinct nuclei (nr) lodged in it. Pyle (1940) in C. promethea makes no mention of the regenerative cells. In S. deesae (Alam, 1953) shows each nidus to consist of two to four cells. The nidi are shown to be present at the bottom of the epithelial folds in the honey bee by Snodgrass (1956). The regenerative cells are shown to be absent in P. gamma, A. caia and a few other forms by Mortimer (1965).

Modes of secretion in the ventriculus.— The holocrine mode of secretion very commonly occurs in the ventriculus of U. pulchella. It is carried out in the following two ways.

(a) Squeezing out of epithelial cells.— When the epithelial cells of the ventriculus are heavily loaded with secretory enzymes, their inner wall bursts taking out with it the striated border. The passage, so formed, allows slow oozing of digestive enzymes (En) into the lumen of the ventriculus. Such disintegrated cells are soon replaced by the regenerative cells. Similar mode of secretion is reported by Alam (1953) in S. deesae, but has not been mentioned by Pyle (1940) in C. prometheа.

(b) Delamination of portions of epithelium.— When the secretion of digestive enzymes is required in quick succession, the epithelial cells filled with digestive enzymes are occasionally sloughed off in groups (oEpth). The midi lying underneath these cells are simultaneously activated to replace the epithelium by new cells (nEpth). Alam (1953) in S. deesae comes across an identical mode of secretion, whereas, Pyle (1940) in C. prometheа makes no mention of it.

The opening of the ventriculus into the proctodaeum is guarded by a weak valve (Pvlv). It is formed by the enlarged epithelial cells of the ventriculus at its junction with the proctodaeum. The epithelium of the proctodaeum is not associated

in the formation of this valve. Alam (1953) in S. deesae and Snodgrass (1956) in the honey bee have shown it as a joint contribution of the ventricular and proctodaeal epithelia. The present writer beleives the valve as a simple mechanism which may be taken to regulate the flow of the ventricular contents into the anterior region of the proctodaeum.

Proctodaeum.— The proctodaeum is the last region of the alimentary canal extending from the fifth abdominal segment to the anus. It is clearly divisible into 'intestine' (Int) and 'rectum' (Rect). Burgess (1880) in the milkweed butterfly divides the proctodaeum into 'ileum', 'colon' and 'rectum'. He, further, records the 'caecal sac' as a swelling of the 'colon'. Perhaps, it would be appropriate if the intestine of U. pulchella is taken to represent ileum-cum-colon of D. archippus (Burgess, 1880).

Intestine (Figs. 115, 123 & 124).— The intestine (Int) is a very narrow convoluted tube opening on the right side of the rectum. All along its length, the intestine is overlaid by the malpighian tubules. The epithelium (sEpth) of the intestine is syncytial with small, but distinct nuclei (nu) lying scattered in it. The intestinal epithelium rests upon the basement membrane (BMB) and is internally lined by a distinct intima (In). It is also thrown into small longitudinal folds, which make the lumen (lInt) spacious. A similar syncytial epithelium is reported by Grell (1938) in P. communis. The

muscularis of the intestine consists of a thick circular muscle layer (cmcl). The longitudinal muscle layer is absent. Snodgrass (1956) in the honey bee, too, finds only the circular muscles, whereas, both the circular and the longitudinal muscle layers are shown to be present in S.deesae (Alam, 1953) and L.varicornis (Akbar, 1958). A more or less syncytial epithelium is recorded by Mortimer (1965) in A.caia.

Rectum (Figs. 115, 125 & 126).— The rectum (Rect) is spindle shaped receiving the intestine in its proximal half and opening by the anus (An) at the end of the tenth segment. Its anterior end is blind. The wall of the rectum is impregnated with a number of circular rectal papillae (rp).

The rectal epithelium (sEpth) is a thin syncytial layer thrown into innumerable small folds. In the region of the rectal papillae, it undergoes protrubrances into the lumen. The intimal lining (In) of the epithelium is distinct. External to the epithelium is a layer of circular muscles (cmcl); the longitudinal muscles (lmcl) forming the outermost layer. The circular muscle in the anal region is thickest to assume the function of a sort of sphincter.

The rectal papillae (rp) are found in single and paired forms which are named as mono-papillar and di-papillar types. Histologically, there is no difference in them. A typical rectal papilla is double layered with an enclosed narrow lumen, called papillar lumen (PL), which separates the two layers incompletely in the case of mono-papillar type; whereas, ~~in the~~

in the di-papillar type, the papillar lumen has disappeared due to coalescence of the two layers (Epthrp). The epithelium of the rectal fold branched off (brEpth) to form the layers of the rectal papilla. The inner syncytial one (Ilrp) is broad with distinct oval nuclei (nu) scattered under no definite plan. This is internally covered over by the intima (In) and, thus, may be called as the 'inner layer of the rectal papilla'. The second branch (OLrp) is also syncytial with scattered nuclei. It is distinctly narrow and devoid of the intima and may be called as the 'outer layer of the rectal papilla'. The epithelial portion of the rectal papilla is externally covered over by the circular (cmcl) followed by the longitudinal (lmcl) muscle layers. The space between the outer layer of the papilla and the circular muscle layer contains tracheae (tr) and traces of connective tissue (ct).

Palm (1949) has described the rectal papillae of Insects. In the case of Lepidoptera, he has given two diagrams with a very concise note on them in the text. However, these may be taken to represent the 'mono-papillar' and 'di-papillar' types of rectal papillae of U. pulchella. Pyle (1940) in C. premethea records only one type of rectal papilla, which is considered analogous to the 'mono-papillar' type of U. pulchella. Taking into consideration the rectal papillae of U. pulchella, C. premethea (Pyle, 1940) and Lepidoptera (Palm, 1949), it can be suggested that in details the rectal papillae of Lepidoptera differ from the rectal papillae of Hymenoptera (S. deesae, Alam,

1953; and the honey bee, Snodgrass, 1956) where, at least, one of the two layers is distinctly cellular.

The present writer ascribes the function of absorption of water to the rectal papillae. In U.pulchella, the inner wall of the rectal papillae absorbs watery contents from the faecal matter and diffuses them into their lumina. From here, the water reaches the outer wall on its way to the blood in the haemocoele. In this way, the rectal papillae play an important part in water conservation.

(ii) The Salivary Glands (Figs. 23, 25, 26, 115, 127 & 128).—

The salivary glands (SlDl) consist of a pair of long, convoluted, narrow tubes lying between the mesothorax and the second abdominal segment. Each gland runs anteriorly along the side of the oesophagus. On reaching the middle of the mesothorax, it takes a backward turn to run upto the end of the thorax. It again takes up an anteriorly directed course and on reaching the prothorax dilates to form the salivary reservoir (ResS). The latter tapers to form the short lateral salivary duct (lSD). The two lateral ducts converge into the cranium where they unite to form the short common salivary duct (SlD) which runs below the sucking pump to open (slo) at the base of the food meatus. Just before its opening, the common duct expands to form the salivarium (slv).

The contour of the salivary gland is wavery. Its syncytial,epithelium (sEpth) is heavily laden with cytoplasmic granules (gn). The large, oval shaped nuclei (nu) are scattered

1953; and the honey bee, Snodgrass, 1956) where, at least, one of the two layers is distinctly cellular.

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The salivary glands (SlGl) consist of a pair of long, convoluted, narrow tubes lying between the mesathorax and the second abdominal segment. Each gland runs anteriorly along the side of the oesophagus. On reaching the middle of the mesothorax, it takes a backward turn to run upto the end of the thorax. It again takes up an anteriorly directed course and on reaching the prothorax dilates to form the salivary reservoir (ResS). The latter tapers to form the short lateral salivary duct (lSD). The two lateral ducts converge into the cranium where they unite to form the short common salivary duct (SlD) which runs below the sucking pump to open (slo) at the base of the food meatus. Just before its opening, the common duct expands to form the salivarium (slv).

The contour of the salivary glands is wavery. Its syncytial, epithelium (sEpth) is heavily laden with cytoplasmic granules (gn). The large, oval shaped nuclei (nu) are scattered

distantly in the cytoplasm under no definite plan. Internally, the epithelium is run over by a distinct intima (In) enclosing a very narrow lumen (lG). External to the epithelium is a thin non-nucleated peritoneal layer (ps). Pyle (1940) in C. premethea records distinct cellular nature of the epithelium containing 'branching' nuclei. The intimal lining is shown to be absent, though the same is shown to be present in the salivary duct of his insect. Further, no mention has been made of the peritoneal layer.

There is no histological difference between the salivary gland and its duct. The outline of the duct is entire. The syncytial epithelium (sEpth) possesses closely placed smaller nuclei (nu). Pyle (1940) in C. premethea records flat epithelial cells.

(iii) The Excretory System (Figs. 115 & 129).— The chief excretory organs are the malpighian tubules (Mal) which are six in number. The three tubules of one side unite to form a short common tubular base which opens into the anterior end of the proctodaeum. The tubules are long and convoluted lying round the mesenteron and the proctodaeum. Each tubule, when stretched, becomes approximately three times longer than the mesenteron.

The malpighian tubules are of almost uniform cross section. The epithelium (Epth) is made up of short cubical cells with faint cell walls and rounded nuclei (nu) located in their

middle. The cytoplasmic granulation (gn) of the cells is fairly dense, whereas, that of the nuclei is faint. There is no intimal lining round the tubular lumen. The basement membrane (BMB) forms the outermost layer while the muscles are absent. The inner border of the epithelium is striated (bb) with short non-convergent striations, resembling the 'brush border' (Buerstensaum) type of striations of insects. In S.deesae, Alam (1953) has shown the presence of both the circular and longitudinal muscle layers. Further, he has recorded a new type of structure which he names the 'conical border'.

The present writer suggests endodermal origin of the malpighian tubules on the basis of the nature of the epithelial cells and the absence of cuticular intima. The presence of striated border further strengthens the contention of the present writer. Henson (1931) in V.urticae, Henialus, P.brassicae and other insects and Alam (1953) in S.deesae also suggest endodermal origin of the malpighian tubules. However, Snodgrass (1956) in the honey bee takes the malpighian tubules as ectodermal in origin.

(iv) The Vascular System (Figs. 130,131, 132 & 133).-

The vascular system of U.pulchella includes the haemocoele, median dorsal vessel, dorsal diaphragm and the ventral diaphragm. The two diaphragms (dDph, vDph) are confined to the abdominal region dividing the haemocoele into three longitudinal chambers, viz., pericardial sinus (pcs), perineural

sinus (pns) and visceral sinus (vs). These sinuses are conspicuous. The pericardial sinus contains the heart, the visceral sinus provides space for the digestive, reproductive and the excretory systems, while, the perineural sinus lodges the ventral nerve cord.

The dorsal vessel.— The tubular dorsal vessel extending from the seventh abdominal segment to the head is divisible into an anterior aorta (Ao) and a posterior heart (Ht). The latter, with uniform cross section, runs under the terga along the midlongitudinal line of the abdomen just dorsal to the digestive tract. It is stretched from the seventh to the second abdominal segment. Therefrom, it bends downwards at right angles to reach the apex of the secondary plate of the third thoracic phragmanotum in the first abdominal segment. The heart, on the basis of paired ostia (Ost), is divisible into seven chambers. This means that the ostia are located at the junction of the two successive chambers. The first chamber (1Ch) is the smallest and lies in the seventh segment. The remaining six chambers are of almost uniform length and are intra-segmental in location which means the seventh chamber (7Ch) lying in the second abdominal segment. The formation of the ostium can be attributed to the tapering condition of the anterior end of a chamber overlapped by the expanded posterior end of the successive chamber lying in the preceding segment. The tapering tip of the chamber becomes the passage for the flow of blood in postero-anterior direction.

The aorta (Ao) is the anterior slender and narrow part of the dorsal vessel stretched from the first abdominal segment to the head. In the first abdominal segment, it runs along midlongitudinal line of the undersurface of the secondary plate of the third thoracic phragmanotum. On reaching the metathoracic segment, the aorta again dives and flanking the apical portion of the second thoracic phragma, takes up a horizontal course to extend parallel but dorsal to the oesophagus upto the meso-scutellum. Therefrom, the aorta ascends and by making a loop comes down to the level of the oesophagus in the anterior region of the meso-scutum. Extending forward, the aorta runs across the prothorax and the neck to enter the head through the foramen magnum. Within the head, the aorta passes through the circumoesophageal ring dorsal to the pharynx. On emerging from the circumoesophageal ring, it runs along the posterior surface of the second dorsal dilator muscle of the pharynx to end by a wide funnel(fAo) just below the frons. In the mesothorax, a small dorsal diverticulum (K) is given out from the apex of the loop. This diverticulum takes up a posteriorly directed ascent and piercing through the bundles of the indirect and principal depressor of the fore-wings, ends very close to the meso-scutellum. It may be taken as the pulsatile organ supplying blood to the fore-wings and can be compared with the 'aortic diverticulum' of Sphinx convolvuli (Brocher, 1919). Further, in the mesothoracic region, the loop is suspended from the indirect and principal depressor and the levators of the fore-wings by fine membranous suspensions. The

latter can be compared with the narrow web of connective tissue suspending the aorta of orthopteroid insects (Nutting, 1951).

The dorsal diaphragm.— The dorsal diaphragm (dDph) is a horizontal continuous sheet of membrane stretched underneath the abdominal dorsum and forms a continuous bed for the heart. It, thus, incompletely separates the pericardial sinus from the visceral sinus. Laterally, the diaphragm is attached to the anterolateral angles of the seventh to the third terga and is, thus, suspended by five pairs of points of suspension from the abdominal dorsum. The lateral margins of the diaphragm are corrugated to allow communication between the pericardial and the visceral sinuses. The diaphragm contains five pairs of subtriangular alary muscles (dDphMcl). Each alary muscle has its vertex fixed at the antero-lateral angle of the tergum concerned, wherefrom, the fibres diverge directed mesally to end by spreading on the lateral surface of the heart. The first and fifth pairs of alary muscles provide suspension to the first and second chambers and to the sixth and seventh chambers, respectively. The remaining alary muscles (second, third and fourth pairs) end on the third to fifth chambers.

The ventral diaphragm.— The ventral diaphragm (vDph) of U. pulchella is confined to the abdominal region only. It is a continuous narrow sheet of membrane stretched from second to the sixth abdominal segments. It is composed of

poorly developed connective tissue and roofs over the ventral nerve cord. The corrugated lateral margins of the ventral diaphragm enable the perineural sinus to communicate with the visceral sinus. The alary muscles (vDpMcl) of the ventral diaphragm are represented by eight paired groups of muscle fibres arising by comparatively narrow bases on the lateral-third of the second to sixth sterna with the first pair of a muscle being the largest. The divergent fibres of the muscles end by broad insertion on the sides of the ventral nerve cord. Richards (1963) in Lepidoptera also shows the reduced condition of the ventral diaphragm with smaller alary muscles and numerous attachments on segments concerned. Gerould (1938) in Bombyx mori L., has not shown the ventral diaphragm.

(v) The Respiratory System.

The respiratory system of U. pulchella consists of nine pairs of open spiracles, tracheae and air sacs. The first two pairs are located in the inter-pleural areas between first and second and between second and third thoracic segments. The remaining seven pairs are in the segmental pleura of the first seven abdominal segments. The first pair of thoracic spiracles and the abdominal spiracles are, more or less, similar whereas, the second pair of thoracic spiracles considerably differ from them.

Spiracles (Figs. 134, 135, 136, 137, 138 & 139).

First pair of thoracic spiracles.— The first thoracic spiracle is an oval shaped aperture (spap) encircled by a narrow sclerotic ring called spiracular rim (spr). It leads into a sunken atrium (Atr) whose inner wall possesses finger like projections (fa) densely clothed with fine hairs. Thus the atrium is supplied with a filtering apparatus to prevent foreign matters from entering the respiratory system. Similarly, Beckel (1956) in Hyalophora cecropia L., finds the 'filter apparatus' at the bottom of the atrial chambers whereas, Tonapi (1959) in Corycera cephalonica S., shows it to arise from the 'peritreme'. Ventrally, the spiracular rim is produced into an internal short stumpy ventral process (vp) which is the seat of origin of the occlusor muscle of the spiracle. The atrium leads into the spiracular trachea. Near their junction (As) is an 'Internal Closing Apparatus' for regulating the movement of air. This apparatus consists of anterior and posterior completely sclerotic semi-circles connected through dorsal (dh) and ventral (vh) hinge lines. These semi-circles can better be termed as anterior (vlv) and posterior (pl) lips. The posterior among them is fixed, while, the anterior one is moveable to form the 'valve' of the spiracle. This may be taken to represent the combined 'dorsal process' and the 'valve' of generalised 'Internal Closing Apparatus'. The complete sclerotic nature of the valve of U. pulchella shows that it is a better evolved condition than what is present in typical lepidopterous 'Internal Closing

Apparatus' (Snodgrass, 1935, Fig. 232, H), where it is shown to be partly sclerotised. The middle of the outer surface of the valve is produced into a 'lever' (l) for the insertion of the occlusor muscle. There is no dilator muscle. Tonapi (1959) in C. cephalonica finds that a portion of the atrial wall forms the 'bridge' which can be compared with the posterior lip of U. pulchella. Further, Tonapi (1959) shows a 'lever' flexibly articulated to the 'bridge', whose 'head' is shown to extend from one side in the form of an 'elastic band' opposite the 'bridge'. The 'elastic band' and the 'head of the lever' in combination amount to the valve of U. pulchella. The account of the spiracle given by Tonapi (1959) does not amount to any conspicuous modification from the typical lepidopterous spiracle given by Snodgrass (1935; Fig. 232, H).

Occlusor muscle of the first thoracic spiracle (Fig. 135; No. 158).—

It is a thick muscle arising on the ventral process of the spiracular rim. Ascending obliquely forwards, the fibres are inserted, by a broad base, on the lever of the valve. On contraction, the muscle pulls the lever downwards with the result that the valve is pressed against the non-mobile posterior lip and, thereby, the passage to the trachea is closed. This movement of the valve is made feasible by the presence of the dorsal and ventral hinges. On relaxation of the occlusor muscle, the lever returns to its normal position by its own elasticity. It is functionally similar to the 'occlusor muscle' of C. cephalonica (Tonapi, 1959).

Second pair of thoracic spiracles.— The second thoracic spiracle lies in the inter-segmental membrane between the posterior arm of the meso-epimeron (Epmd2) and meta-episternum (Eps3). It is actually placed very closely to the posterior arm of the meso-epimeron. Comparatively, it is least conspicuous among all the spiracles. The second thoracic spiracle is a crescent shaped aperture (spap) and is enclosed by a semi-circular rim. The periphery of the semi-circle forms the anterior half of the rim (aspr), whereas, the base of the semi-circle becomes the posterior half (pspr). The anterior half is distinctly sclerotised and placed a little external to the posterior half as if incompletely overlapping it. The posterior half is completely membranous. The two halves meet dorsally a and ventrally to complete the semi-circular shape of the spiracular rim. The ventral end of the anterior half is slightly produced downwards to form the ventral process (vp) which provides insertion to the occlusor muscle of the spiracle. The spiracle leads into a short, wide but sclerotic atrium (Atr) whose walls are distinctly reticulate (raw). There is, however, no filtering mechanism which is conspicuously present in the first thoracic spiracle. The semi-circular rim of the spiracle is actually the outermost portion of the atrial wall. The inner end of the atrium is in communication with the short spiracular trachea (spt).

— Occlusor muscle of the second thoracic spiracle (Fig. 136; No. 159).—

It is a short muscle arising on the posterior surface of the mesothoracic furcal arm close to its fusion with the posterior arm of the meso-epimeron. Running in ventro-anterior direction, the parallel fibres of the muscle end on the ventral process of the spiracular rim. The contraction of this muscle will pull the ventral process downwards. The latter, in its turn, will swing the anterior half of the rim backwards with the result that the posterior half of the rim will be run over by the anterior half. Consequently, the spiracle will be closed. In the absence of a dilater muscle, the spiracle automatically opens on the relaxation of the occlusor muscle. The second thoracic spiracle may be considered well equipped with 'External Closing Apparatus'. This is opposed to the type of closing apparatus described in the remaining spiracles of U. pulchella.

Abdominal spiracles.-- All the seven pairs of abdominal spiracles are identical in shape, size and structure. The abdominal spiracle is smaller than the first thoracic spiracle and possesses the same components which form the latter. However, some morphological differences are present. The anterior lip (al) of the closing mechanism is fixed, while, the posterior lip (dp + vlv) is movable. The dorsal half of the posterior lip is sclerotised to form the 'dorsal process' (dp). Its outer surface is produced into the lever (l) for the insertion of the occlusor muscle. The ventral half of the posterior lip is elastic and forms the valve (vlv). This shows that the

'internal Closing Apparatus' of the abdominal spiracle of U.pulchella is much similar to the typical lepidopterous condition, except that the dilator muscle is wanting (Snodgrass, 1935; Fig. 232, H). The occlusor muscle (Fig. 139; No. 160) ascends obliquely backwards, but its function is the same as that of the first thoracic spiracle. Beckel (1956) in H.cecropia calls the anterior lip as the 'closing bow'and the posterior lip as the 'closing band'. The latter is shown to be made up of 'dorsal median','dersal lateral' and 'ventral' closing bars. The first two bars collectively amount to the sclerotic dorsal half of the posterior lip of U.pulchella, while, the 'ventral bar' replaces the elastic ventral half of the posterior lip, i.e., the valve. Since the bars are not shown to function independently, and are operated upon by a single occlusor muscle, the present writer finds no reason to accept them as separate morphological entities. Besides the occlusor muscle, Beckel (1956) finds an'opener' which, he does not consider to be a muscle, but only a 'column' of 'elastic fibres'

It is interesting to note that Tonapi (1959) in C.cephalonica finds all the nine pairs of spiracles similar differing only in size, whereas, in U.pulchella, three different types of closing apparatus are recorded. It appears that Tonapi (1959) has not studied the details of all the spiracles and so might have overlooked the differences in their mechanism.

The tracheal system (Figs. 140, 141, 142, 143 & 144).—

The tracheation of the body is based on the arrangements of the tracheae and the air sacs. It is interesting to note that the arrangement of the air sacs is almost as elaborate as the disposition of the tracheae. Broadly speaking, the tracheal arrangement consists of (i) spiracular tracheae (spt), (ii) lateral trunks (LT), (iii) dorsal tracheae (D), (iv) ventral tracheae (V) and (v) anastomosis of tracheae. The air sacs are, no doubt, numerous but there is no definite plan of their disposition.

The spiracular trachea (spt) connects the spiracle with the lateral trunk. It is usually short, but in the thorax it is further reduced. The lateral trunk (LT) extends along the side of the body from the first spiracle to the dorsal genital air sac in the eighth abdominal segment. All along the course, it receives the spiracular tracheae in the spiracular segments. The trunk has undergone conspicuous dilation in the fifth, sixth and seventh abdominal segments, while, in the second, third and fourth abdominal segments, it expands enormously to form three lateral air sacs (Nos. 21, 22 and 23). In the post-spiracular region of the male, the lateral trunk tapers to end in the unpaired large dorsal genital air sac (No. 17) located in the eighth segment. In the females, the ending of the trunk into the genital air sac is many branched. This sac, in both the sexes, supplies minute branches to the muscles of the genitalia.

Tracheation of the thorax.— The lateral trunk on entering the thorax runs right across the metathorax to enter into the mesothorax, and receives on its outer surface the spiracular trachea of the second thoracic spiracle (spt2). Just opposite to the insertion of the spiracular trachea, the trunk gives out a short branch which bifurcates into a dorsal (D2) and a ventral (V2) trachea. This branch may be called as root trachea (RT2). The latter further gives out another two tracheae, which, on the basis of their relative positions may be called as antero-dorsal (h) and postero-dorsal (j) tracheae.

The dorsal trachea (D2) after its origin runs for a short distance along the posterior margin of the meso-scutellum to end,ultimately, in the unpaired postero-dorsal air sac (No. 8b) of the mesothorax. This sac supplies fine branches to the indirect and principal depressor muscle of the fore-wings.

The ventral trachea (V2) dives down to branch off into an anterior branch (12) going to the middle-leg; a posterior branch (13) which enters the hind-coxa and a middle branch (n) which runs mesally to open into the mesothoracic ventral air sac (No. 10). The latter lies beneath the indirect and principal depressor muscle of the fore-wing and supplies finer branches to the oesophagus.

The antero-dorsal trachea (h) is the largest amongst the four branches and extends forwards mesal to the indirect and principal levator muscle of the fore-wing. On reaching meso-prescutal fissure, it bends inwards to meet its counterpart

of the other side. Throughout the course, its mesal and lateral walls give short branches to the indirect and principal depressor and levator muscles of the fore-wing. The anteriormost of its lateral branches (h1) turns upwards and enters the tegula through the tegular orifice to end into the tegular air sac (No. 9) which is confined within the tegula. Somewhere from the middle of the dorsal surface of the antero-dorsal trachea arises a short trachea which soon divides into an outer branch (W1) going to the fore-wing and an inner branch (h2) which runs mesally to join the unpaired antero-dorsal air sac (No. 8a) of the mesothorax. The latter is, more or less, inverted 'Y' shaped with its arms limited to the posterior half of the scutal region; whereas, the stem portion extends upto the prescutal fissure. This sac also supplies finer tracheae to the indirect and principal depressor muscle of the fore-wing, and is situated above the latter.

The postero-dorsal trachea (j) is posteriorly directed and soon after its origin sends a branch (W2) to the hind-wing. On reaching the lateral portion of the metascutum, the postero-lateral trachea ends into the metathoracic dorso-lateral air sac (No. 12). Mesally, this air sac gives out a short branch which connects it with the unpaired dorso-anterior air sac (No. 11a) of the metathorax, which is situated beneath the metathoracic scutellum. Posteriorly, the latter sac is in communication with the unpaired subtriangular dorso-posterior air sac (No. 11b) of the metathorax which extends into the

first abdominal segment running below the secondary plate of the third thoracic phragmanotum. The dorso-posterior air sac gives out an oblique trachea from its side to connect it with the metathoracic ventro-lateral air sac (No. 13). The latter lies in the meta-epimeron close to the tympanal membrane.

The lateral trunk extends forwards across the meso-thorax and receives the first thoracic spiracular trachea (spt1) in the prothorax. The trunk gives out a short root branch (RT1) which immediately divides into a dorsal (D1) and a ventral (V1) trachea. Close to the point of bifurcation arises an anteriorly directed trachea called the anterior trachea (e).

The dorsal trachea (D1), running mesally, ends into the prothoracic unpaired dorsal air sac (No. 4) which lies just beneath the protergum and supplies branches to the protergal muscles, levator muscles of the head and also to the aorta. The dorsal trachea gives off an upper (f) and a lower (f2) branch. The upper branch, running upwards, enters the patagium to end into the patagial air sac (No. 5); whereas, the lower branch descends to communicate with the prothoracic lateral air sac (No. 6) which is situated on the side of the oesophagus and supplies fine branches to the latter.

The ventral trachea (V1) gives off anterior (g), middle (c) and posterior (g1) branches. The anterior branch ends into the prothoracic unpaired ventral air sac (No. 7). Before joining the air sac, the anterior branch sends a narrow

trachea (11) to the fore-leg. The ventral air sac (No. 7) is a large oblong shaped sac lying beneath the oesophagus. It extends from the middle of the prothorax to the first thoracic ganglion supplying branches to the latter, and also to the muscles of the fore-leg. Anteriorly, this sac gives off a paired trachea (d) for the head, which, on the basis of its position in the head is termed as the ventral cranial trachea. The middle branch of the ventral trachea(c) loops to enter the head where it takes up a ventro-lateral position. It may be called as ventro-lateral cranial trachea (c). The posterior branch (g1) is the longest among the three branches and running posteriorly supplies branches to the ventral nerve cord and its ganglia in the thorax.

The anterior trachea (e) before entering the head divides into a dorsal and a ventral branch. On the basis of their position inside the head, these may be named as dorsal cranial (a) and dorso-lateral cranial (b) tracheae, respectively.

Tracheation of the head.— The head receives four pairs of tracheae from the first thoracic spiracles, the first three enter the head through the upper half of the foramen magnum, while, the fourth one passes through its lower half.

The dorsal cranial trachea (a) running dorsal to the oesophagus, fuses with its counterpart of the other side in the neck region, but before entering the head, the fused trachea

branches off into an upper dorsal cranial trachea (a1) and a lower dorsal cranial trachea (a2). The first one soon ends in the dorsal cranial air sac (No. 1) which is fairly large and is situated above the brain. From the dorso-lateral surface of this sac arises a small branch (oc) which goes to the lateral ocellus; whereas, from its antero-lateral surface another branch (AnT) comes out for the antenna. Posteriorly, the dorsal cranial air sac sends several minute branches to the brain. The lower dorsal cranial trachea (a2) running beneath the dorsal cranial air sac, opens into the anterior cranial air sac (No. 2), which is larger than the former and lies in the fronto-clypeal region. This air sac supplies branches to the muscles of the sucking pump.

The dorso-lateral cranial trachea (b) runs along the side of the oesophagus to enter into the head. It gives out a ventrally directed short branch (b1) for the suboesophageal ganglion. The main trachea runs flanking the posterior tentorial arm and bifurcates into a dorsal (b2) and a ventral (b3) branch. The former runs along the dorsal half of the ocular rim supplying finer branches to the eye and ultimately opens into the anterior cranial air sac. The ventral branch (b3) descends obliquely inwards to end into the posterior cranial air sac (No. 3). Dorsally, the ventral branch gives out three tracheae; two of which (Nos. b4 and b5) go to the adductor muscles of the stipes while the third one (b6) ramifies into the hypopharynx.

The ventro-lateral cranial trachea (c), running along the ventral half of the ocular rim, supplies branches to the eye. Anteriorly, it bifurcates into an outer branch (c1) going to the adductor muscles of the stipes and an inner branch (c2) for the labral compressor muscle. Just before bifurcation, it gives out two parallel tracheae (c3 and c4) which ascend to and into dorso-lateral cranial trachea (b).

The ventral cranial trachea (d) runs on the floor of the head ventral to the pharynx to open into the posterior cranial air sac (No. 3) which is located between the sucking pump and the labium. From the middle of this trachea, two branches (d1 and d2) come out to connect it with the dorso-lateral cranial trachea. Ventrally, the posterior cranial air sac gives out a long trachea (d3) which extends into the lumen of the galea.

Tracheation of the abdomen.— The tracheation in all the spiracle bearing segments is almost similar, but the last spiracle bearing segment (seventh segment) in both the sexes and the fifth segment in the male show modifications, which will be dealt with later. The lateral trunk continues into the abdomen upto the seventh segment and receives short spiracular tracheae (1spt-7spt) in segments first to the seventh. In spiracle bearing segments, the trunk gives out a dorsal (D) and a ventral (V) trachea from its dorsal and ventral surfaces, respectively.

The dorsal trachea (D) divides into an upper (o) and a lower (p) branch. The upper branch (o) in the first abdominal

segment opens into a small dorso-lateral air sac (No. 20) which lies close to the lateral tergite of the first abdominal segment and supplies finer branches to the tympanal muscles. From the inner surface of the dorso-lateral air sac arises a mesally directed trachea which ends into the unpaired lower dorsal air sac (No. 14b) placed above the secondary plate of the third thoracic phragmanotum. In the second segment, the upper branch of the dorsal trachea extends forwards to end into the unpaired upper dorsal air sac (No. 14a) of the preceding segment which is subtriangular in shape. The upper branch in third segment opens into the segmental unpaired dorsal air sac (No. 16) which may be taken analogous to the unpaired lower dorsal air sac (No. 14b) of the first segment. The upper and lower dorsal air sacs of the first segment and the dorsal air sac of the third segment supply minute branches to the heart, dorsal diaphragm, digestive tract and the tergal muscles. In the remaining spiracle bearing segments, the upper branch is not associated with any air sac and directly supplies small ramifications to the heart, dorsal diaphragm, digestive tract and the tergal muscles.

The lower branch (p) of the dorsal trachea of the first segment ends into the segmental unpaired upper dorsal air sac (No. 14a). The lower branch of the second and third segments opens into an irregularly shaped unpaired dorsal air sac (No. 15) situated in the second segment, and may be taken analogous to the upper dorsal air sac of the first abdominal

segment. The same branch of the dorsal trachea, in the rest of the spiracle bearing segments supply btanches to the digestive and the reproductive organs.

The ventral trachea (V) of spiracle bearing segment originates from the ventral surface of the lateral trunk. It is ventral to the lateral air sacs (Nos. 21, 22 and 23) in the second to fourth abdominal segments. The ventral trachea divides into an upper (q) and a lower (r) branch. The upper branch (q) supplies minute branches to the digestive and reproductive organs while the lower branch redivides into an anterior (r1) and a posterior (r2) branch. The anterior of the two meets its counterpart of the other side below the ventral nerve cord to form a ventral commissure (rr). The posterior branch (r2), on the other hand, sends minute branches to the nerve cord and the sternal muscles. In the first segment, however, it is the posterior branch (r2) which forms the commissure, while, the anterior branch ends into the ventro-lateral air sac (No. 24). The latter is situated in the first abdominal segment flanking the metathoracic dorso-posterior air sac. The trecheation in the fifth segment of the male and the seventh segment of the male and female have undergone modifications. In the fifth segment of the male, the dorsal trachea (5D), before its bifurcation, gives out a mesal branch called the testicular trachea (S). The latter subdivides into four branches (S1-S4); two of them anastomose over the antero-lateral surface of the testis, while, the other two profusely branch over its postero-lateral

surface.

The dorsal trachea of the seventh segment (7D) in the male before bifurcation gives out a stout mesal branch (t) which runs posteriorly for a short distance and then turns inwards, thereby, dividing into an upper (td) and a lower (tv) branch. These branches run above and below the rectum, respectively, to meet their counterparts of the other side. Thus, an upper (tc1) and a lower (tc2) commissure is formed which combiningly encircle the rectum. The lower commissure sends a short branch to the undersurface of the rectum and also a comparatively prominent branch, called genital trachea (tg), The latter, after entering the ninth segment, bifurcates; the upper branch (tgd) running posteriorly ends into the post-genital unpaired dorsal air sac (No. 19) and, on its way, also supplies finer branches to the muscles of the genitalia. The post-genital dorsal air sac is very small and is located in the tubular tenth tergum. The lower branch (tgv) of the genital trachea splits up into two lateral tracheae. Each lateral trachea divides into an inner (tgv1) and an outer (tgv2) branch. The inner one supplies branches to the rectum; while, the outer one sends minute branches to the parамere and is named as parameral trachea.

In the seventh segment of the female, the posterior half of the lateral trunk gives out a stout trachea (U) which ramifies over the reproductive organs. The dorsal trachea of this segment (7D), before bifurcation, gives out a narrow

anteriorly directed branch (Y) for the heart and a prominent mesal branch (M) which converges backwards to meet its counterpart of the other side near the posterior margin of the seventh tergum. From this junction two lateral and one median trachease are given out. The lateral trachea (M1) take up ventrally directed course and, on reaching near the postero-lateral angle of the eighth tergum, ends by numerous short branches which go th the muscles of the pseudo-ovipositor. The median trachea (M2) extends posteriorly to open into the unpaired inter-segmental dorsal genital air sac (No. 18) placed between the eighth tergum and the pseudo-ovipositor. This sac supplies fine branches to the pseudo-ovipositor and is in communication with the dorsal genital air sac (No.17) through paired lateral tracheae.

(vi) The Male Reproductive System (Fig. 145).

The male reproductive system consists of the usual components. The testis (Tes) is a single globular mass which represents the condition of 'complete fusion' of the gonads as has been recorded in higher Lepidoptera. It gives out from the ventral side a pair of vasa deferentia (vd) , which open into the corresponding seminal vesicle (vsm). The latter is continued further by a narrow seminal duct (sd) which opens into the reservoir of the accessory gland (ResAcGl). The accessory glands (AcGl) consist of a pair of long narrow convoluted tubes which basally dilate to form the reservoirs. The latter converge posteriorly to open into the common duct of

the accessory glands(edAcGl). This duct is large and highly convoluted and ends into the ejaculatory duct (Dej) which posteriorly enters the aedeagus (Aed) to open at the apex of the invaginated endophallus.

Testis (Figs. 145 & 146).— The testis, in a freshly killed moth,is dark brown and slightly dorso-ventrally flattened. Riding over the alimentary canal in the third abdominal segment this globular organ is formed by complete fusion of the paired embryonic gonads, and is enclosed in a distinct peritoneal sac. The latter is externally wrapped by fine branches of the testicular trachea. In an old male, it is shrunk into a small rounded body, which has moved from its original position to the fourth abdominal segment.

The testis consists of eight testicular follicles (Fol) which are separated from each other by incomplete septa (Sep). The outermost layer surrounding the testis is the thin, structureless and transparent peritoneum (ps). Ruckes (1919) in Lepidoptera finds a similar layer over the entire reproductive organs and, considering it to have formed from the fused walls of the tracheae, calls it as the 'tracheal membrane,' Srivastava (1960) in L. orbonalis does not record the presence of any such layer. The peritoneum is followed by the epithelial sheath which may be split up into an outer epithelium (epo) and an inner epithelium (epi). Similar double layered epithelium has also been reported by Alam (1953) in S. dessae. The outer epithelium is a thin syncytial layer with faint granulation

Its nuclei (nu) are oval and scattered under no definite plan. Ruckes (1919) in Lepidoptera calls such outer epithelial layer as the 'capsular coat' consisting of a single row of distinct cuboidal cells with spongy and granular cytoplasm. Similarly, Musgrave (1937) and Srivastava (1960) in E. kuhniella and L. orbonalis have called it as 'cellular layer' and 'outer cellular wall' respectively, having clear cellular nature. However, in their relevent figures, such cellular nature is not conspicuous (Musgrave, 1937, Fig. 16; Srivastava, 1960, Fig. 4). Alam (1953) in S. deesae has shown the outer epithelium as thin and non-nucleated which he considers comparable with the 'outer tunica' of Diptera. Akbar (1958) in L. varicornis has also reported the presence of an outer epithelium containing pigment granules.

The inner epithelium is also syncytial and is as thick as the outer epithelium. The oval and prominently granulated nuclei (nu) are much more numerous. This epithelial layer is easily detectable by the presence of dark brown pigment granules (pepi) which give dark brown colour to the testis. A similar syncytial inner layer is reported by Musgrave (1937) in E. kuhniella. Ruckes (1919) in Lepidoptera calls such pigmented layer as the 'testicular tube coat' and suggests that the cells are separated from one another by large inter-cellular spaces containing cytoplasmic ramifications of the periphery of cells. He, further, maintains that the shape of the cells varies in different species of Lepidoptera. Srivastava (1960) in L. orbonalis

calls the inner epithelium as the'inner cellular layer' consisting of strongly pigmented flat cells with rounded nuclei. Alam (1953) and Akbar (1958) in S. deesae and L. varicornis, respectively have recorded syncytial nature in the inner epithelium.

Musgrave (1937) in E. kühniella has recorded fine non-cellular layer lining the cavity of the testicular chambers. However, he has failed to show this layer in any of his figures on the testis. Similar incomplete and doubtful observation has been made by Srivastava (1960) in L. orbonalis.

The inner epithelium is continued for short distance into the testicular lumen in the form of seven filamentous septa (Sep) which divide the testis into eight incomplete testicular follicles (Fol). Each septum is fairly thick at the base and gradually thins out apically. Srivastava (1960) in L. orbonalis records the cellular nature of the septa, near the boundary region, but his Fig. No. 4 does not support this observation.

The lumen of the testis contains the germ cells at various stages of development which are scattered in the lumen. The primary germ cells are the spermatogonia (Spg). As the spermatogenesis proceeds, the spermatogonium subdivides and the daughter spermatogonia are encysted to form the sperm cysts (Cst). The sperm cyst, later on, develops into spermatids (Spd).

The latter are transformed into bundles of mature spermatozoa called the spermatodiams (Spz). The free spermatozpa are not present in the lumen of the testis.

Vas deferens and Seminal vesicle (Figs. 145, 147, 148 & 149). The two vasa deferentia arise separately by broad base from the ventral surface of the testis. These, flanking the mid-gut, descend dorso-ventrally directed to open into the seminal vesicles. Prior to opening into the latter, the vas deferens becomes markedly narrow. The seminal vesicle is nothing but distended form of the vas deferens. The seminal vesicle opens into the reservoir of the accessory gland by a long narrow tubular duct. The opening of the seminal duct directly into the reservoir of the accessory gland may be a novel feature in Lepidoptera; but it does occur in higher insects as has been demonstrated by Alam (1953) in S. dessae.

The epithelium (Epth) of the vas deferens is externally bounded by the peritoneal layer (ps) which is in continuation with the peritoneum of the testis. The epithelium is composed of very tall, columnar, densely granulated cells . The nuclei (nu) are oval with prominent granules (gn) and are situated near the periphery of the cells. The entire epithelium is thrown into folds,so that, the lumen becomes narrow and star shaped. Musgrave (1937) in E. kuhniella has recorded the 'brush border' condition of the epithelium. The present writer, however, failed to detect 'brush border' condition in U. pulchella. The

vas deferens does not possess any muscle layer as is also the case in L. orbonalis (Srivastava, 1960). Musgrave (1937) in E. kühniella is doubtful about its presence. Ruckes (1919), however, reports the presence of a circular muscle layer in the Saturnidae.

The outermost layer of the seminal vesicle is the peritoneum (ps) which is a continuation of the peritoneum of the vas deferens. The epithelium (Epth), enclosing the spacious lumen, consists of short cubical cells resting on a distinct basement membrane. The cells are finely granulated (gn). The nuclei are centrally placed (nu) with distinct granulation (gn). Ruckes (1919) in Lepidoptera finds the epithelium to be made up of columnar cells. Musgrave (1937) in E. kühniella records the epithelium as a combination of the cellular and syncytial conditions.

The seminal duct is regular in cross section and the epithelium (Epth) is externally bounded by the peritoneum (ps). The tall columnar cells rest on a distinct basement membrane (BMB) and do not form any villus. The nuclei (nu) are located basally and possess distinct chromatin granules (gn).

Accessory gland (Figs. 145, 150, 151, 152, 153, 154 & 155).— There is a pair of tubular accessory glands which are long and highly convoluted. These are brought closer due to connecting tracheae. Each gland is of uniform width and is apically blind. It opens into its reservoir which is comparatively much wider.

The reservoir of the accessory gland is short, broad and tubular and posteriorly converges to open into the common duct of the accessory gland. The latter is long, tubular and highly convoluted occupying the greater portion of the visceral sinus of the abdomen. It ultimately opens into the ejaculatory duct.

Histologically, the accessory gland consists of a wide syncytial epithelium (sEpth) and is devoid of the peritoneum. The epithelial nuclei (nu) are large, oval and irregularly scattered. These are heavily laden with chromatin granules (gn) while the cytoplasm is poorly granulated. The epithelium is externally surrounded by a thin circular muscle layer (cmcl). Ruckes (1919) in Lepidoptera has shown columnar epithelium covered w externally by a longitudinal muscle layer. Musgrave (1937) in E. kuhniella divides the accessory gland into four subdivisions.

The epithelium of the reservoir of accessory gland is also syncytial (sEpth) enclosing a spacious lumen. It is poorly granulated and contains oval nuclei (nu) arranged in a regular manner. The nuclei are prominent and possess distinct chromatin granules. The epithelium rests on a clear basement membrane (BMB) which is externally bounded by a thin layer of circular muscles (cmcl). The reservoir functions as a temporary storage for the sperms and provides them with an opportunity to get mingled with the secretion of the accessory gland and its

reservoir. Musgrave (1937) in E.kühniella is doubtful about the presence of muscles and shows the epithelium to be secretory in nature. He, further, records the'paired gland' to be separated anteriorly from the accessory gland and 'posteriorly from the 'paired gland' by a'partition'at both ends. No such partition is, however, available in U.pulchella nor is it reported by Ruckes (1919) in Lepidoptera and Srivastava (1960) in L.orbonalis. Further, the latter author shows no muscle layer around the epithelium, which is made up of cubical secretory cells.

The reservoir of the accessory gland has been called the 'ductus ejaculatorius duplex' by Ruckes (1919) in Lepidoptera and 'paired ejaculatory duct' by Srivastava(1960) in L.orbonalis. The present writer is not prepared to accept this view as the two authors have failed to show any intimal lining in it. On the other hand, Srivastava (1960) attributes secretory nature to it. Norris (1932) in E.kühniella and P.interpunctella and Musgrave (1937) in E.kühniella also consider it as secretory centre, and, therefore, call it as the 'paired glands'.

The common duct of the accessory gland, besides being a passage for the descent of sperms, is secretory in nature, as well. On the basis of different secretions, this duct is conveniently divided into four portions whish are separated from each other by distinct constrictions. The reactions of these secretions to the stains (Haematoxylin with Eosin as counter stain) have been taken as criteria for subdividing the

common duct of the accessory gland into four portions.

The first portion of the common duct is the longest portion separable from the reservoir by a distinct constriction. The epithelium (Epth) is very narrow, faintly cellular with oval nuclei (nu). Inconspicuous chromatin granules are scattered in the epithelium, as well as, in the nuclei. The epithelium is externally bounded by a circular muscle layer (cmcl). The spacious lumen contains the secretion (Secr) of the epithelium. The secretion is arranged in six subtriangular lumps whose bases rest on the periphery of the epithelium. These lumps are deeply stained with Haematoxylin.

The second portion is subequal to the first portion. Its epithelium (Epth) is wider and consists of short columnar cells. The epithelium exhibits fine foldings. The cytoplasm is finely granulated with centrally placed rounded nuclei (nu). The latter are big and thickly granulated. The epithelium is encircled byth circular muscle layer (cmcl). The lumen is filled with the secretion (Secr) which consists of homegeneous rounded oil globules arranged, more or less, in whorls. These are brightly stained with Eosin.

The third portion is the shortest. Its epithelium (Epth), with cubical cells, consists of fairly granulated cytoplasm. The nuclei are centrally placed, rounded in shape and densely granulated. The outermost covering of the epithelium is represented by a circular muscle layer (cmcl). The lumen

is filled with yellowish secretion (Secr) which is heterogeneous in nature containing granules and vacuoles. The granules are responsible for for the yellowish coloration of the contents of the lumen and take up Eosin stain. The vacuoles donot pick up the stain.

The fourth portion is longer than the third portion and posteriorly opens into the ejaculatory duct. The epithelium (Epth) is narrow and faintly cellular with a spacious lumen. The cytoplasm of the epithelium is faintly granulated, while, the nuclei (nu) are big and conspicuously rounded. A circular muscle layer forms the outer cover of the epithelium. The lumen contains thin continuous accumulation of the epithelial secretion (Secr) which consists of fine granules and is completely devoid of oil globules and the vacuoles. This secretion is deeply stained with Haematoxylin.

Ruckes (1919) in Lepidoptera, following the terminology of Schroeder (1912), calls the common duct of the accessory glands plus the ejaculatory duct as 'ductus ejaculatorius simplex'. The reservoirs of the accessory glands have been taken as 'ductus ejaculatorius duplex'. Further, Ruckes (1919) does not consider any portion of 'ductus ejaculatorius simplex' as secretory. Norris (1932) in E. kühniella and P. interpunctella has called this portion as 'unpaired gland' divisible into four portions. Musgrave (1937) in E. kühniella agrees with Norris (1932) but further suggests to divide it into eight subdivisions with four of them

as distinct unpaired glands.~~glands~~. He is not certain to call the remaining (intermediate) four portions as true glands. Srivastava (1960) in L. orbonalis calls the common duct and the ejaculatory duct as 'unpaired ejaculatory duct'. He, further, shows that a portion of the 'unpaired ejaculatory duct'('non-muscular glandular region') is divisible into three regions on the basis of secretions.

Ejaculatory duct (Figs. 145, 156, 157 & 158).— The unpaired ejaculatory duct is short and convoluted and measures about one-third of the length of common duct of the accessory glands. Anteriorly, it communicates with the fourth portion of the common duct of the accessory glands, while, posteriorly, it enters into the aedeagus to open at the apex of the endophallus. The entire ejaculatory duct is enveloped by a thin peritoneum, which is fairly loose on its middle region.

The syncytial epithelium (sEpth) rests on a distinct basement membrane (BMB) and is provided with distantly placed rounded nuclei (nu). Prominent chromatin granules (gn) are present in the nuclei, as well as, in the cytoplasm of the epithelium. The inner wall of the latter is run over by a thick intima (In) which becomes more thickened posteriorly. The intimal lining of the distal portion of the ejaculatory duct bears a large number of short spines (sn). Externally, the ejaculatory duct is surrounded by a thick layer of circular muscles (cmcl) which separates it from the peritoneum (ps). Anteriorly, a small portion of the ejaculatory duct (bej) becomes

conspicuously wider and highly muscular. This portion can be compared with the 'bulbus ejaculatorius' of E. kühniella and P. interpunctella (Norris, 1932). The circular muscles (cmcl) are so arranged on the bulbus ejaculatorius that its lumen is dislodged from its central position. Similarly, Norris (1932) records only the circular muscle layers in the ejaculatory duct of E. kühniella and P. interpunctella. Ruckes (1919) in Lepidoptera has shown much elaborate arrangement of these muscles. Srivastava (1960) in L. orbonalis calls the ejaculatory duct as the 'muscular chitinous region of the unpaired ejaculatory duct'. He observes that the epithelium is separated from the basement membrane by thick layers of circular and longitudinal muscles. It appears that he has taken the normal peritoneum for the basement membrane in his insect.

The 'ductus ejaculatorius simplex' in Lepidoptera is shown by Ruckes (1919) to contain intimal lining throughout its length. This portion corresponds to the combined form of the common duct of accessory glands and the ejaculatory duct of U. pulchella. Srivastava (1960) in L. orbonalis also shows one long ejaculatory duct with intimal lining confined to its distal end only which he names as 'muscular chitinous region of the unpaired ejaculatory duct'. This can be compared with the ejaculatory duct of U. pulchella. The 'non-muscular glandular region' of the ejaculatory duct is also shown as part of the ejaculatory duct in L. orbonalis by him. This suggestion appears

to be far removed from the generally accepted basic fact pertaining to the ejaculatory duct in insects. Norris (1932) in E.kühniella and P.interpunctella and Musgrave (1937) in E.kühniella have shown a short 'ductus ejaculatorius' which can be compared with the ejaculatory duct of U.pulchella. These authors have also shown the presence of an unpaired gland of complex nature corresponding to the common duct of accessory glands of U.pulchella. So far as the ejaculatory duct is concerned, there is no dispute as they have shown the presence of intimal lining on its epithelium. According to the above authors, the 'unpaired glands' consist of four definite glandular units arranged in linear manner and communicating with each other, thereby, forming one continuous lumen. Such end-to-end relationship of these glands is not in consonance with the general mode of opening of the glands in the ejaculatory duct (independent communication with the ejaculatory duct or through a common duct). The present writer in U.pulchella, therefore, calls the entire structure as common duct of accessory glands secondarily equipped with secretory function.

(vii) The Female Reproductive System (Fig. 159).

The paired ovaries containing four ovarioles (Ovl) each are followed by two lateral ducts (Odl), which unite to form the common oviduct (Odc). The latter continues posteriorly to open into the vagina (vag) which communicates with

the exterior, in the ninth segment, through the oviporus. Like other Ditrysia, the bursal orifice (bo) is located in the inter-sternal membrane of the seventh and the eighth sterna. The bursal orifice leads into a short bursal duct (bd) and the latter ends into the bursal sac (bs). A narrow seminal duct (sd), arising from the bursal duct, opens ventrally into the anterior end of the vagina. The unpaired spermatheca with its tubular gland (SptGl) and a pair of accessory glands (AcGl) complete the female reproductive organs. The spermatheca opens into the dorsal wall of the vagina at the level of the opening of the seminal duct. The vaginal apex receives, in its right wall, the opening of the accessory glands.

Ovary.— The ovary is large and conspicuous and lies dorso-lateral to the alimentary canal. When mature, it occupies the major portion of the visceral sinus. It consists of four ovarioles which extend from the seventh to the second abdominal segment. The ovarioles are very long and coiled with tracheae interweving them togather. Each ovariole is divisible into a short apical germarium (Grm) and a long, convoluted, beaded like vitellarium (Vtl). The terminal filament is not traceable.

Ovariole (Figs. 159, 160 & 161).— The short germarium is externally enclosed in a thin, smooth, non-nucleated peritoneal layer (ps) and is filled with a mass of primordial germ cells. The latter give rise to the oocytes (Ooc), the nurse cells (NrC) and the follicular cells (fc).

The germarium is followed by the conspicuously beaded vitellarium. The beads are the follicles (egg chambers) which become bigger and bigger towards the oviduct. This can be attributed to the developing stages of the oöcytes (Ooc). Each follicle (fo) is a compound structure containing the developing oöcyte and the nurse cells (NrC) aggregated the oöcyte being always posterior to the nurse cells which are three to five in number. The follicular epithelium (fEpth) around the oöcyte consists of columnar cells, whereas, its portion enclosing the nurse cells is made up of comparatively cuboidal cells. The nuclei (nu) are finely granulated, while, the cytoplasm is thickly granulated. The follicular cells are borne on a distinct basement membrane (BMB). The epithelium of the follicle slightly extends (ex) between the oöcyte and the nurse cells but does not discontinue their intercommunication. In E. kühniella, Musgrave (1937) shows that the oöcyte and the nutritive chambers are completely separated from each other by an intervening septum but their intercommunication is maintained through an aperture in the septum.

The nutritive cells (NrC) are large and irregular with richly granulated cytoplasm. Their nuclei (nN) are big but poorly granulated. Norris (1932) in E. kühniella and P. interpunctella and Musgrave (1937) in E. kühniella find very large, lobate nuclei in the nurse cells. As development proceeds, the nurse cells slowly disintegrate yielding their

contents to the growing oöcyte. Each oöcyte is spherical in shape and full of yolk (ylk). The rounded nucleus (N) is quite distinct. A structureless chorion (Ch) is secreted by the follicular epithelium around the fully developed oöcyte.

Oviducts (Figs. 159 & 162).— The four ovarioles of each side, basally, unite to form the lateral oviducts (Odl) which converge to open into the short common oviduct (Odc). The outermost layer of the lateral oviduct is the thick longitudinal muscle layer (lmcl) followed by the circular muscle layer (cmcl). A similar arrangement of the muscularis is present in L. varicornis (Akbar, 1958) while a reverse condition exists in L. orbonalis (Srivastava, 1960). Allman (1930) in C. pomonella, Norris (1932) in E. kühniella and P. interpunctella and Alam (1953) in S. deesae record only the circular muscle layer in their respective insects. Malouf (1930) and Snodgrass (1956) in Nezara viridula L., and the honey bee, respectively, have shown the longitudinal muscle layer only. The muscle layer is followed by convoluted epithelium (Epth) which rests on a distinct basement membrane. It consists of small cubical cells whose boundaries are very faint but their nuclei (n) are distinct. The epithelial cells, as well as, their nuclei are densely granulated (gn). In C. pomonella, (Allman, 1930), E. kühniella (Musgrave, 1937) and L. orbonalis (Srivastava, 1960) the epithelium of the lateral oviduct is similar to that of U. pulchella. However, Musgrave (1937) has shown the basement

membrane as indistinct.

The histological details of the common oviduct are exactly similar to those of the lateral oviduct, with the only difference that its lumen is comparatively more reduced. In E. kühniella (Musgrave, 1937), the epithelium of the common oviduct is shown to be syncytial. Musgrave (1937) distinguishes the cells only by their nuclei and occasional cell boundaries. Akbar (1968) in L. varicornis and Srivastava (1960) in L. orbonalis show that the circular muscles are external to the longitudinal muscles, a condition just the reverse of what is present in U. pulchella.

Srivastava (1960) in L. orbonalis has clearly shown the presence of a dilated 'vestibule' representing the posterior portion of the common oviduct and functioning as a connecting passage between the lumina of the common oviduct and the vagina. Exactly identical location of the 'vestibule' had earlier been shown by Norris (1932) in E. kühniella and P. interpunctella and Musgrave (1937) in E. kühniella, respectively. It is surprising that Srivastava (1960) did not consider it necessary to compare the 'vestibule' of his insect with that of E. kühniella (Norris, 1932; Musgrave, 1937), though, he had referred these papers in the list of his references.

Most probably, these authors, by the term 'vestibule'

mean the 'vestibulum'* of insects as defined by Snodgrass (1933). Since the definition of the 'vestibulum' given by Snodgrass (1933) is still valid, the present writer can not resist pointing out to Srivastava (1960) and others that the 'vestibule' of their insects can not be taken as a part of the common oviduct. Akbar (1958) in L. varicornis has proved the stability of the definition of the 'vestibulum' given by Snodgrass (1933).

Vagina (Figs. 159, 163 & 164).— The common oviduct opens through the gonopore into the tubular vagina (vag) of almost uniform diameter which communicates with the exterior through the oviporus. Its anterior limit is anatomically marked by the opening of the spermatheca. Similarly, the posterior limit is externally represented by the opening of the accessory glands. It can, therefore, be compared with the 'genital chamber' of L. varicornis (Akbar, 1958)

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* "When the seventh sternum is extended beyond the eighth sternum (fig. 8C), the latter (VIIISt) is generally reduced in size, and may become rudimentary, or it is retained only as a small plate on the floor of the genital chamber containing the gonopore. This condition is characteristic of Termitidae, Blattidae, Hemiptera, and Hymenoptera.

"The extension of the seventh abdominal sternum beyond the eighth produces a second cavity (fig. 8C, Vst) lying above the seventh sternum, which becomes an antechamber to the primary genital chamber (GC), or a continuation of the latter, and may be distinguished as the vestibulum."

The vaginal epithelium (sEpth), resting on a distinct basement membrane (BMB), is narrow, syncytial and thrown into innumerable small folds. The distantly placed oval shaped nuclei (nu) are scattered without following a definite plan of arrangement. The epithelium is internally lined by a thin intima (In). In the vicinity of the opening of the accessory glands, the intima becomes highly thickened and the epithelial folds become deeper. The syncytial nature of the vaginal epithelium is also reported by Musgrave (1937) and Srivastava (1960) in E. kühniella and L. orbonalis, respectively. Musgrave (1937) has not shown the basement membrane and suggests that the 'hypodermis' is lost in the connective tissue. Allman (1930) in C. pomonella records the cellular nature of the vaginal epithelium and observes that the chitinous lining becomes much more pronounced on the ventral wall in its posterior exsertible portion. The vaginal epithelium of U. pulchella is externally bounded by a thick layer of longitudinal muscles (lmcl), followed by the circular muscle layer (cmcl). Musgrave (1937) and Srivastava (1960) in E. kühniella and L. orbonalis, respectively, have not shown any definite plan of disposition of the longitudinal and circular muscles.

Spermatheca (Figs. 159, 165, 166 & 167).— The spermatheca is mostly tubular in shape. Before opening into the vagina by the spermathecal duct (Sptd), it gets dilated to form a

distinct reservoir (Sptr). The spermatheca lies coiled among the female reproductive organs. Its lumen is narrow and surrounded by a prominent wavery chitinous lining (In). The epithelium (sEpth) is very broad and completely devoid of any cell boundaries. The oval nuclei (nn) are arranged under no definite plan. No muscle layer exists, nor it is reported in other Lepidoptera (E. kühniella, L. orbonalis etc.). Norris (1932) in E. kühniella and Srivastava (1960) in L. orbonalis have recorded large columnar epithelial cells. Musgrave (1937) in E. kühniella describes two layers of 'hypodermal' cells.

The reservoir is oval in shape. Its wall consists of externally lying circular muscle layer (cmcl) followed by the epithelium (sEpth) which is thrown into small folds. The cellular demarcation in the epithelium is not clear, but, the nuclei (nn) are arranged in, more or less, a regular manner. Both the nuclei and the epithelium possess cytoplasmic granulations (gn). The epithelium rests on a distinct basement membrane (BMB) and is internally lined by a thin intima (In). The lumen is spacious. Allman (1930) in C. pomonella has not shown the muscular coat. Norris (1932) and Srivastava (1960) in E. kühniella and L. orbonalis have recorded distinct cells in the epithelium. In E. kühniella, Musgrave (1937) has shown the syncytial nature of the epithelial layer, and records a peculiar arrangement of the muscle fibres.

The lumen of the spirally coiled spermathecal duct

is much reduced due to deep villi borne by the epithelium (Epth). The latter is cellular and made up of columnar cells resting on the basement membrane (BMB). The cells are granulated with basally arranged nuclei (nu). The epithelium is internally lined by a thick intima (In). One of the folds (villus) is conspicuously deep having strongly thickened intimal lining. This makes the duct look like bi-luminal in form (x,z). Similar condition in E. kühniella has encouraged Musgrave (1937) to show the presence of two distinct lumina ('subsdiary' and 'true' lumina). Norris (1932) in E. kühniella and P. interpunctella, Musgrave (1937) in E. kühniella and Srivastava (1960) in L. orbonalis also find spirally coiled spermathecal duct which is shown to open on a papilla like structure called the 'infundibulum'. The present writer, however, fails to record any such structure in U. pulchella.

Bursa copulatrix (Figs. 159, 168 & 169).— The bursa copulatrix is a fairly large sac like structure opening to the exterior through the bursal duct (bd) at the bursal orifice (bo) and extends into the visceral sinus under the digestive tract, upto the fourth abdominal segment. It can conveniently, be divided into the bursal sac (bs) and the bursal duct. A narrow seminal duct connects the bursal duct with the vagina.

The epithelium (Epth) of the apical half of the bursal sac is composed of small cuboidal cells with centrally placed large nuclei (nu). The epithelial cells are finely granulated (gn). In the basal half of the bursal sac, the cell boundaries are incomplete. The epithelial layer of the entire bursal sac is internally lined by a thick intima (In) which becomes all the more thickened basally. In a portion of the side walls of the bursal sac, the intima is greatly thickened so as to form two small oval plates (OP) which bear several short spines. These oval plates have been named as 'lamina dentata' by lepidopterists (Norris, 1932 in E.kühniella and P.interpunctella; Musgrave, 1937, in E.kühniella and Klots, 1956 in Lepidoptera). The bursal sac is externally surrounded by a muscle layer (mclr)which is composed of typical circular fibres in the region of the basal half of the bursa. The muscle fibres, in the apical half of the bursa, assume radiating concave course with their ends on the laminae dentata of the side walls. The present writer attributes shortening of the bursal sac to the radiating muscle fibres. This would enable the spermatophores to descend into the basal portion of the bursal sac from its apical half. The typical circular muscles of the basal half will now break the spermatophores and the sperms, so released, are pumped into the seminal duct. It is, therefore, suggested that the apical half functions as real store for the spermatophores during copulation, whereas, the basal half becomes a passage for the flow of the sperms

into the seminal duct for onward transmission to the spermatheca. The intimal lining is shown by Allman (1930) in C.nomonella to be invaginated in the form of two narrow 'funnels' which are considered by him to provide attachment to the muscles, radiating from them. Musgrave (1937) in E.kühniella reports the presence of inter-twining longitudinal and circular muscles in the region of the 'lamina dentata', while, only circular muscles are shown to be present in the posterior portion. No muscularis is , however, shown to be developed in the'most anterior portion'of the bursa of E.kühniella and L.orbonalis (Musgrave, 1937 and Srivastava, 1960). Norris (1932) in E.kühniella and P.interpunctella shows the epithelium to be made up of hexagonal epithelial cells internally bound by a thick intima and externally by a peritoneal layer enclosing poorly developed musculature. The latter is shown by her to be strongly developed in the region of the 'folds'.

The bursal duct is curved and dorso-ventrally flattened, leading from the bursal orifice to the posterior end of the bursal sac. Histologically, the bursal duct is composed of a narrow syncytial epithelium (sEpth) with closely placed nuclei (nu). Internally, the epithelium is lined by a very thick intima (In) thrown into innumerable small folds. Externally, the epithelium is enclosed by a thin layer of circular muscles (cmcl). The histological deatils of the posterior portion of the bursal duct, near the bursal orifice, differ for

having increased intima and the absence of the circular muscle layer.

Seminal duct (Figs. 159, 170 & 171).— This narrow duct (sd) connects the bursal duct with the vagina. The proximal half of the seminal duct is comparatively broader than its distal half. From the middle of the duct, comes out a small diverticulum (bsem). This may be compared with the 'bulla seminalis' of E.kühniella and P.interpunctella (Norris, 1932). No such structure has been reported by Srivastava (1960) in L.orbonalis.

The epithelium (Epth) of the seminal duct is composed of cubical cells with large centrally placed nuclei (nu). The latter contain few but distinct chromatin granules (gn), whereas, the cytoplasm of the cells is richly granulated (gn). Internally, the epithelium is run over by a thick intima (In) with distinct spines (sn) sparingly borne by it. In the middle of the seminal duct, the intima becomes very thin and the spines are lost. As the duct reaches the vagina, its intimal lining becomes more thickened and the spines reappear. The outermost layer of the seminal duct is the circular muscle layer (cmcl) which gradually thins out towards the vagina. Srivastava (1960) in L.orbonalis records, more or less, similar histology of the seminal duct with the difference that the circular muscle layer is uniform throughout. Musgrave (1937) in E.kühniella records the cellular nature of the epithelium but

does not show it in his Fig. No. 11 A and B. Further, he records the musculature consisting of both longitudinal and circular layers which are absent in the middle portion of the duct. The diverticulum has almost similar histology. However, the nuclei (nu) are comparatively larger and heavily laden with granules (gn). The inner wall of the epithelium is highly irregular. The intimal lining (In) is thin. The diverticulum is devoid of muscle layer. Musgrave (1937) in E. kühniella, on the other hand, demonstrates the presence of longitudinal, as well as, circular muscle layers.

Accessory gland (Figs. 159, 172, 173 & 174).— The paired accessory glands (AcGl) are long, tubular and convoluted structures, lying in the posterior region of the visceral sinus. Each gland, before opening, dilates into an oblong, sac like transparent reservoir (ResGl). The latter, lying dorsal to the rectum, tapers to unite with its counterpart of the other side. The fused portion is now drawn out into a short, narrow duct of the accessory gland (dAcGl). This opens into the lateral wall of the vagina in the vicinity of the oviporus. The fluid discharge of the gland is transparent and is used for glueing the eggs on the substratum. This function is confirmed from the fact that the fully filled reservoirs always collapse after oviposition. Allman (1930) in C. pomonella shows the glands to open into a common reservoir. Musgrave (1937) in E. kühniella has called them as 'cement glands'.

The wall of the accessory gland, in its apical half, consists of tall, columnar cells which are internally lined by a distinct intima (In). The lumen is narrow. In the basal half, the lumen of the gland becomes spacious and the cells cuboidal. The epithelial cells are provided with oval shaped prominent nuclei (nu) containing few but distinct chromatin granules. The cytoplasm, on the other hand, is richly granulated. The cells have mono-vacuolated condition, which changes to multiple-vacuolated condition in the basal portion of the gland. Allman (1930) in C. pomonella reports the presence of a'peritoneal membrane' and,also, multi-nucleated condition of the cells. Musgrave (1937) in E. kühniella finds a, more or less, syncytial epithelium. The lumen of the reservoir is very spacious and is bounded by the narrow syncytial epithelium (sEpth) which is faintly granulated. The oval nuclei (nu) are distantly scattered in the cytoplasm. The duct of the accessory glands is provided with a thick coat of circular muscles (cmcl) around the epithelium (Epth). The latter is made up of columnar cells with rounded and distinctly granulated nuclei (nu) placed in the periphery of the cells. The epithelium is internally lined by a thin intima (In). Srivastava (1960) in L. orbonalis shows a syncytial epithelium and the presence of longitudinal muscles in addition to the circular muscles. Musgrave's (1937) account shows that the muscles are not disposed under any definite plan.

Attractant gland (Figs. 88, 113 & 175).— It is composed

of a pair of highly convoluted, narrow, tubular glands (SG), lying in the visceral sinus of the female. The two glands posteriorly meet to form a very short common duct which opens in the inter-segmental membrane between the eighth and ninth terga. The epithelium (sEpth) of the gland is syncytial and granulated (gn). The densely granulated nuclei (nu) are arranged in a regular manner. Externally, the epithelium rests on a definite basement membrane (BMB), while, internally, it is lined by a thick intima (In). The intimal lining is produced into long, pointed processes (InPr). The muscularis consists of an inner layer of circular muscles (cmcl) and an outer one of longitudinal muscles (lmcl). The latter is represented by four bundles of fibres. The histology of the common duct is exactly identical to that of the gland. The secretion of the gland is mildly alkaline. The present writer thinks that the secretion of this gland serves to attract the male for mating. No such gland is reported by Allman (1930) in C. pomonella, Norris (1932) in E. kühniella and P. interpunctella, Musgrave (1937) in E. kühniella and Srivastava (1960) in L. orbonalis.

(viii) The Nervous System.

The study of the nervous system embodies observations on the Central Nervous System and the Stomodaeal Nervous System.

The Central Nervous System (Figs. 176, 177 & 178).— The central nervous system consists of the brain (Br), the suboesophageal ganglion (SoeGng) and the ventral nerve cord (VNC). The brain is situated above the pharynx while the suboesophageal ganglion

lies below it within the cranium. The ventral nerve cord bears six ganglionic masses of the trunk region.

Brain with its nerves.— The brain (Br) is pale white and consists of the usual three parts, viz., protocerebral (1Br), deutocerebral (2Br) and tritocerebral (3Br) centres. The paired centres are so fused together that their anatomical identity can not easily be made out. However, these can be pinned down on the basis of nerves coming out from them.

The protocerebrum (1Br) is the largest among the subdivisions of the brain and contributes to its dorsal half. The two lobes of the protocerebrum fuse by their entire mesal surfaces and the line of fusion of these two lobes is externally visible by a faint longitudinal groove (gr). The protocerebrum, dorso-laterally, gives out a pair of short, stout ocellar nerves (OlNv) going to the lateral ocelli. Likewise, the lateral portions develop the paired optic lobes (OpL) for the innervation of the compound eyes (E). These optic lobes are demarcated from the protocerebrum along a distinct external constriction.

The deutocerebrum (2Br) is not clearly demarcated from the protocerebrum. It can, however, be identified by the pear shaped paired antennal lobes (AntL) which are borne by it. These give out antennary nerves (AntNv) for the innervation of the antennae and their muscles.

The tritocerebrum (3Br) is the smallest portion of

the brain forming its ventral portion. It is faintly demarcated from the deutocerebrum, while, its lateral portions are drawn downwards to meet the suboesophageal ganglion. These drawn out structures may be taken as short circumoesophageal connectives (CoeCon) enclosing a circular passage for the pharynx to pass through. The tritocerebrum gives out two pairs of distinct nerves. The inner nerve , frontal ganglion connective (frCon), after encircling the first dorsal dilators of pharynx end on the frontal ganglion (frGng). The latter gives out a posterior recurrent nerve (fNv) to be described along with the stomodaeal nervous system, and an anterior frontal nerve (fNv) to innervate the muscles of the sucking pump and the food meatus. The outer nerves, labral nerves, arising from the tritocerebrum, soon bifurcate; one of the branches merges with the first sub-branch of the frontal nerve, while, the other (LmNv) goes to the labrum.

Suboesophageal ganglion.— The subtriangular shaped suboesophageal ganglionic mass (SoeGng) lies below the pharynx, and is formed by the fusion of the mandibular, maxillary and the labial ganglia, which are very closely packed within a common external covering. The main four paired nerves (mandibular, hypopharyngeal, maxillary and labial nerves) are given out from the sides of the suboesophageal ganglion in antero-posterior direction. These go to the respective appendages. The anteriormost pair of nerves, mandibular nerves (MdNv), is also found to innervate the area of the head capsule which

possesses the mandibles. The present writer suggests that this nerve represents the generalised mandibular nerve which is still retained, inspite of the fact that the mandibles have become non-functional. Because of the reduction of the mandibles to non-functional entity, this pair of nerves has also secondarily taken over the innervation of the area of the head capsule which possesses the mandibles. Eastham and Eassa(1955) in P.brassicae have shown that because of the withdrawal of the mandibles from active use, the mandibular nerves have completely disappeared. Similarly, Ehrlich and Davidson (1961) in D.plexippus have not shown the mandibular nerves in their fig. No. 13. The paired hypopharyngeal nerves (HphyNv), coming out from the suboesophageal ganglion, supply branches to the hypopharynx and the salivary ducts. The maxillary nerves (MxNv) are fairly thick and enter the lumina of the stipites to continue into the galeae. The posterior-most pair of nerves, the labial nerves (LbNv), arises from the suboesophageal ganglion posterior to the hypopharyngeal nerves to supply branches to the labium. Besides the main nerves, a pair of cervical nerves (CNv), coming out from the posteriormost part of the suboesophageal ganglion, branches off in the neck region.

Ventral nerve cord.— The ventral nerve cord (VNC) bears six dark brown ganglionic centres (1Gng-6Gng) arranged in linear manner along the mid-ventral longitudinal line of the trunk. Each ganglionic mass is a fusion product of the

primitive paired segmental ganglia. The second and the sixth ganglionic masses are of compound nature. The first two ganglionic masses are comparatively bigger and confined to the venter of the thorax and, consequently, called the thoracic ganglia. The first ganglion (1Gng) belongs to the prothoracic segment. The second thoracic ganglion (2Gng) is a composite one formed by the fusion of the mesothoracic, metathoracic and first two abdominal ganglia. The first three abdominal ganglia (3Gng-5Gng) represent the third to fifth segmental ganglionic centres and are, thus, simple ganglia. The last (fourth) abdominal ganglion (6Gng) is a compound one, made up of sixth to ninth segmental abdominal ganglia.

The prominent first thoracic ganglion (1Gng) is oval and rides the pro-endosternum. It gives off several paired nerves, of which five are important ones. Anteriorly, two pairs of nerves arise from its ventro-lateral surface; the anterior pair ramifies over the extrinsic muscles of the head, whereas, the posterior one (1N1) bifurcates. One of its branches enter the fore-legs; the second one branches over the extrinsic muscles of the fore-coxa. The postero-lateral surface of the ganglion gives origin to two pairs of nerves which supply minute branches to the muscles of the prothorax. The fifth unpaired nerve is short and is called the median nerve (MN1). Immediately after the origin, this nerve bifurcates

to innervate the first pair of thoracic spiracles. It also receives a branch from the first nerve of the second thoracic ganglion.

The second thoracic ganglion (2Gng) is oval shaped and is located on the midlongitudinal ridge of the mesothoracic basisternum just anterior to the origin of the meso-furcal arms. This ganglion gives out seven pairs of prominent nerves from its sides; the first five pairs, arising from its anterior half, innervate the mesothorax, while, the remaining two pairs are given out from its posterior half to innervate the metathorax. Besides, an unpaired median nerve (MN2) originates from the dorsal surface of the ganglion. The first (anterior-most) nerve is fairly thick and, arising ventrolaterally, soon divides into two branches; the first branch merges with the median nerve of the first thoracic ganglion, while, the second branch (WN1) undergoes sub-branching to innervate the fore-wing, the indirect and principal depressor of the fore-wings. The second, third and the fourth pairs of nerves run upwards to supply branches to the indirect and principal levator muscles of the fore-wings, the extensor muscles of the fore-wings and the tergal promotors of the coxae. The fifth (posterior most) pair of nerves gives out three branches on each side; one (1N2) of which enters the lumen of the middle-coxa to innervate the middle-leg and its intrinsic muscles, while, the remaining two branches go to the extrinsic muscles of the middle coxa.

The two pairs of nerves, originating from the posterior half of the second thoracic ganglion, innervate the metathoracic segment and may be considered as the first and second pairs of metathoracic nerves. The first among them is fairly thick and gives out branches to the intrinsic and extrinsic muscles of the hind-legs (1N3), the hind-wings (WN2), indirect and principal depressor muscles of the hind-wings and the second pair of thoracic spiracles. The second pair sends branches to the muscles of the hind-wings and the extrinsic muscles of the hind-legs.

The unpaired median nerve (MN2) is short and arises from the mid-dorsal area of the second thoracic ganglion. It soon divides into two branches which immediately merge with the first metathoracic nerve of its respective side.

The portion of the ventral nerve cord, connecting the second thoracic ganglion with the third abdominal ganglion (3Gng), gives out two paired nerves; the anterior (1AN) among them enter the first abdominal segment to innervate the tympanal muscles, the first abdominal spiracles and the muscles of the first abdominal segment. The posterior pair of nerves (2AN) supplies branches to the second abdominal segment, sending a branch to the second pair of abdominal spiracles as well. The innervation of the first and second abdominal segments suggests the merger of the first and second abdominal ganglia with the second thoracic ganglion.

The third, fourth and fifth ganglia (3Gng-5Gng) are small and rounded and located in the anterior half of the third to fifth abdominal segments. Each ganglion gives out a pair of lateral nerves (LN) for the segment concerned. This nerve, on each side, runs laterally and then ascends along the segmental pleuron to end by several branches innervating the dorsal diaphragm and the heart. On its way, the lateral nerve sends branches to the muscles of its segment. In the pleural region, it innervates the segmental abdominal spiracle through a fine nerve branch. Just anterior to each abdominal ganglion, an unpaired median nerve (MN) is given out from the dorsal surface of the ventral nerve cord. The median nerve soon divides into two diaphral nerves (dN) which go to the ventral diaphragm. The diaphral nerves are also connected with the segmental lateral nerves of the following ganglion. Just anterior to the sixth abdominal ganglion of the female, such a median nerve is given out. Beckel (1956) in H. cecropia shows three pairs of nerves coming out of the abdominal ganglion and named them as 'anterolateral, mid-lateral and posterolateral nerves. The 'antero-lateral' and the 'mid-lateral' nerves are comparable with the median and the lateral nerves of U. pulchella. Libby (1961) in the same insect, calls these nerves as 'transverse, dorsal and ventral' nerves, respectively.

The sixth abdominal ganglion (6Gng) is a composite

one made up of the sixth, seventh and eighth abdominal ganglia of the larva. It gives out three paired and one unpaired nerves in the male and six paired nerves in the female to innervate the segmental structures beyond the sixth segment.

In the males, the sixth abdominal ganglion (6Gng) gives out three paired and one unpaired nerve. The anterior pair of nerves (NA) innervates the sixth segment, while, the middle one (NM) divides into two branches which go to the seventh and eighth segments. The posterior pair (NP) is very thick and divides into two branches which go to the retractors of the anal tube and to the depressors of the tenth tergum. These nerves give out a short branch close to their origin which loop around the vasa deferentia to rejoin the same nerves. The posterior nerves send branches to the adductor muscles of transtilla and to the rectum (RN). Another branch arises anterior to the rectal branch for the innervation of the protractor and retractor muscles of the aedeagus, the muscles of the parameres and of the basal plate. The unpaired nerve (UN) arises from the posterior surface of the ganglion to innervate the ejaculatory duct and the aedeagus. Libby (1961) in H. cecropia shows ten pairs of nerves arising from the 'terminal ganglion', three pairs each for the sixth, seventh and eighth *segments*, and one pair for the reproductive organs and the genitalia.

In the case of females the sixth ganglion gives off lateral paired nerves (6LN) in its anterior half. The lateral nerves are fairly thick whose branches innervate the sixth

segment. The posterior half of the sixth abdominal ganglion gives out five pairs of nerves. The first pair (Nf1) innervates the seventh segment. The second one (Nf2) soon divides into two branches; the outer among them supplies to the ventral muscles of the seventh segment, whereas, the inner one ramifies over the accessory glands and the rectum. The third pair of nerves (Nf3) gives branches to the intestine, accessory glands and the pseudo-ovipositor. The nerves of the fourth pair (Nf4) innervate the eighth segment and send branches to the bursa copulatrix, the seminal duct and the muscles of the pseudo-ovipositor. The last pair of nerves (Nf5) ramifies over the accessory glands, the vagina and the muscles of the pseudo-ovipositor.

The Stomodaeal Nervous System (Figs. 176 & 179).— The stomodaeal nervous system of U. pulchella consists of the frontal ganglion (frGng) and hypocerebral ganglion (hGng). The frontal ganglion is subtriangular and flattened. It is placed dorsally at the junction of the cibarium and the pharynx, and is connected with the tritocerebrum (3Br) by a pair of frontal ganglion connectives which encircle the first dorsal dilators of the pharynx. The frontal ganglion, anteriorly, gives out an unpaired frontal nerve (fNv) whose branches go to the muscles of the cibarium and the food meatus. Posteromedially, the recurrent nerve (rNv) comes out from the frontal ganglion and, running backwards along the mid-dorsal line of the pharynx underneath the aorta, ends on the anterior tip of the

hypocerebral ganglion. The latter is small and is apparently hardly broader than the recurrent nerve. It is placed on the dorsal wall of the stomodaeum within the craniumbelow the aorta. Bickley (1942) in Prodenia eridania C., calls it the 'occipital ganglion' and attributes its formation to the fusion of the median parts of the corpora cardiaca and the recurrent nerve. The hypocerebral ganglion, from its posterior face, gives out an unpaired recurrent nerve, which, adhered to the dorsal surface of the oesophagus, extends backwards upto the junction of the oesophagus and crop. Here, the recurrent nerve bifurcates and the two branches ramify over the crop. There is no trace of any stomachic ganglion. The recurrent nerve, from its middle, gives out a pair of fine nerves (AoNv) to the aorta. In P. eridania, Bickley (1942) records the paired condition of the 'oesophageal nerve' and shows it to give off several branches for the innervation of the salivary glands, oesophagus and the crop . He, too, does not report the presence of the stomachic ganglion.

The paired corpora cardiaca (Cc) are distinctly oval and longer than the hypocerebral ganglion. These are placed lateral to and a little higher to the hypocerebral ganglion. The latter gives out a short connective to put it in communication with the corpora cardiaca. The corpora cardiaca are closely appressed against the walls of the aorta, and are anteriorly connected with the protocerebrum through a pair of distinct nerves, called 'paracardiac' nerves (pcNv).

Bickley (1942) in P. eridania shows the fusion of the median parts of the corpora cardiaca.

The paired corpora allata (Ca) are very small, lying ventral to, and in close association with the corpora cardiaca. The unusually short connecting ducts between the corpora allata and the corpora cardiaca are normally not detectable. Bickley (1942) in P. eridania shows that the dorsal parts of the corpora allata are connected with each other.

5. THE LIFE-HISTORY.

(1) Introduction.—

Sann hemp (Crotolaria juncea L.) is an important crop of India. In recent years, its importance has increased manyfold because of the trend to bring more land under cultivation of Sann hemp. Utetheisa pulchella L., is a serious pest of this crop. The larva is not only a leaf feeder but also attacks other parts of the plant. Lefroy (1909) records it as widely scattered all over the old world, while, Fletcher (1914) reports its occurrence from South India. Lal (1917), Sen (1917), Ratiram (1917) and Shroff and Fletcher (1917) have reported it from Punjab, Bengal, Central Provinces and Burma respectively. Recently, Teotia and Pathak (1966) and Srivastava et al (1963) have recorded it from Uttar Pradesh. The present writer has collected it from Sann hemp fields in Aligarh and the surrounding districts.

Fletcher (1914) has given a very short account of the life-history of U. pulchella. Ayyar (1940) is no improvement on Fletcher's work. Recently, Srivastava et al (1963) have made some interesting observations on its life-history. The total absence of detailed observations on this insect has inspired the present writer to make a detailed study of its life-history under controlled conditions (Temperature, 29° C; Relative Humidity, 75% ± 5%). Side by side, observations of important stages were recorded in the field and have been inserted in the text at their proper places.

The present writer has selected the study of certain aspects of behaviour of U. pulchella with the idea of popularising insect behaviour which is far from satisfactory in India. It is, further, felt that the study of behaviour of U. pulchella is very likely to become a guiding factor for the effective control of this pest. Recently, Alam (1962, 1957 & 1958) has recorded useful observations on various aspects of behaviour in parasitic insects. Dhillon (Ph.D., Thesis) has further expanded Alam's approach to insect behaviour by studying it in Athalia proxima Klug.

(ii) Technique of Breeding.--

The adult moths were collected with the help of hand-nets from grass patches around the fields of C. junceus. For rearing purposes, circular glass jars (3" x 4") were used. These rearing jars contained sand filled to one-fourth of their depth. The males and females were confined in the rearing jars by closing their open ends with the help of muslin pieces wrapped round them. The elastic rubber bands were used to keep the muslin pieces in position. The moths were fed on sugar solution in a feeding watch glass. The feeding technique required a solid watch glass (1" x 1" x ½"), cotton piece and filter paper. The cavity of the watch glass was filled with sugar solution and a small piece of cotton was drowned in the solution. The watch glass was covered with a piece of small filter paper (1"x1"). The feeding watch glass, so prepared, was put in a rearing jar containing four pairs of moths. This

feeding technique proved very satisfactory as it amounts to a definite improvement over the ordinary method of feeding moths on sugar solution. The satisfactory aspect of this technique is that the moths were prevented from entangling their legs in cotton fibres, which usually results in the death of the moths.

The rearing jars (8"x4") were filled with sand to their one-fourth depths. The sand was wetted with water. Small twigs of Sann hemp plants were fixed in it so as to be saved from becoming dried. These jars were kept in constant temperature cabinet adjusted to 29° C with 75% ±5% relative humidity. The humidity was controlled by keeping rectangular glass troughs filled with KOH solution prepared as suggested by Buxton and Mellanby (1934).

The larvae, on hatching, were transferred to feeding jars containing fresh twigs of Sann hemp fixed in moist sand. The tender leaves, serving as source of food, were changed twice a day. The late (fourth and fifth) instars could survive on twigs, and pods, besides the leaves, which are essential only for early instars. When the Sann hemp season was over, and no leaves or pods were available, considerable difficulty was experienced in the rearing of this insect. This difficulty ranged from late November (harvesting of crop) to early July of the following year. To overcome this difficulty, and to get a regular supply of the insects round the year, the following method was evolved. The seeds of Sann hemp were soaked in

water for twenty-four hours. These seeds were then placed on moist sand in the rearing jars which kept the seeds soft for twenty-four hours. The larvae were released on these seeds and were found to survive. Daily change of seeds soaked in water prevented the seeds, as well as, the larvae from fungal attacks. This technique enabled the present writer to continue breeding of U. pulchella round the year in the laboratory. The present writer, further, strengthened this technique by using seeds of Cajanus cajan L., (Arhar) in place of Sann hemp-seeds and found the larvae equally interested in this alternative food.

(iii) Habits of the Adult.--

The adult moth is found active during the day time. Ordinarily, it is found in the grass near Sann hemp fields. It is not a fast flier, and, when disturbed, flies for a short distance only. The moth is positively phototropic as it is attracted to fluorescent tube, when placed near the fields. The adults appear in the fields in the month of March and are available till December, excepting the month of June. These disappear from the fields from Jan. to March. However, in the winter months (December to February) the pest has been observed in pupal form on the dry leaves of the harvested Sann hemp crop.

(iv) Nature and extent of damage.--

It is the larval stage of U. pulchella which destroys the Sann hemp crop. The larvae, soon after hatching, start

feeding on the plants. The first instar larva nibbles only the epidermis of the young leaves. The second instar larva feeds on the epidermis, as well as, the cortex, whileg the third instar eats the entire leaves including their veins leaving the mid-rib. The penultimate (fourth) instar larva is found boring into the young pods to feed on the developing soft seeds. After finishing the seed, it comes out to attack the other pods. As a rule, only one larva enters a pod, but sometimes, upto three larvae have been recovered from a single pod. The last (fifth) instar feeds on all parts of the plant (leaf, stem, pod) excepting flower and root.

The extent of damage, caused by this pest, depends on the severity of infestation. Sometimes, high intensity of infestation causes complete destruction of the crop irrespective of its age. Under normal conditions, the maximum damage was recorded from fields during October and November, which, obviously, means that the last two instars are most destructive to the crop, thereby, becoming of greatest concern for the agriculturists. Srivastava et al (1963) seem to have overlooked the severity of damage in respect to the larval instars.

(v) Copulation.—

Twenty five pairs of the pest were used in the study of the copulation behaviour of U. pulchella. The adults

emerged under laboratory conditions did not copulate for 24 hours. This may be taken as precopulation period (Table No. 1). In four cases, however, the copulation did not take place before 60 hours, which may be taken as exceptions. Pairs of the moth were kept in 25 rearing jars. The copulation was observed during the day time; but it can also occur in nights if artificial light is available. The initiative for copulation was taken by the male by coming very close to the side of the female. If the female did not move away on the approach of the male, the latter started tapping the side of her abdomen by bending his abdominal apex towards her. The unwilling female would fly away on tapping the abdomen but a willing female was found responding to the male by raising her abdomen. This made the male to move his abdominal apex further close to the female to grip her abdominal apex with his parameres. After the male had gripped the female, he moved away from her along a semi-circular course till the mating partners assumed an end-to-end posture. The male's grip of the female did not allow disengagement. On assuming this posture, the male inserted his external genitalia into the bursa copulatrix to enforce copulation, which, normally, lasted for one hour. Ordinary disturbance in the area would not mean disengagement and the pairing individuals would just move away.

In the field, the pre-copulation period was recorded to be 30 hours (Table No. 1).

Table No. 1. Comparative table of life-cycle in constant temperature room and in the field.

S.No.	Different periods of life-cycle.	Average duration in C.T. Room. Temperature 29° C. R.H. 75% ±5%.	Average duration in the field.
1.	Pre-copulation period.	24 hours.	30 hours.
2.	Pre-ovipositian period.	50 hours.	55 hours.
3.	Incubation period.	63 hours.	80 hours.
4.	First instar	67 hours.	78 hours.
5.	Second instar	49 hours.	67 hours.
6.	Third instar	51 hours.	72 hours.
7.	Fourth instar	54 hours.	75 hours.
8.	Fifth instar	81 hours.	92 hours.
9.	Pupal period.	123 hours.	144 hours.
	Total period required for completing one life-cycle.	23 days and 10 hours.	28 days and 21 hours.

(vi) Oviposition.--

Since this moth easily copulates in captivity, it was not difficult to observe the actual mode of oviposition. Fifteen pairs of moths, emerged under laboratory conditions, were kept in fifteen jars. After copulation, the males were removed. The females laid first batch of eggs, at an average,

fifty hours after copulation (Table No. 1). In the field, however, the pre-oviposition period came to 55 hours (Table No. 1). Srivastava et al (1963) have recorded this period to vary between one and two days.

When the female was ready for oviposition, it became a little restless and moved here and there, probably, in search of a suitable site. On locating the desired site, it stood motionless for some time and then started tapping the spot with her pseudo-ovipositor. This was immediately followed by the descent of an egg through the pseudo-ovipositor. The egg was firmly attached to the substratum with the help of colourless secretion from the accessory glands. The eggs, so laid, were deposited in batches with eggs varying in number from one to twenty eggs per batch with an average of four eggs(Table No. 2). This observation is at variance with that of Srivastava et al (1963) who have never recorded more than 5 eggs per batch.

There was a lot of variation in the number of eggs laid by different females during their life time. The maximum number of eggs laid by a single female was 306, while, the minimum number went down to 117. However, the average number of eggs laid by a female was 205.8 (Table No. 2). The observations of Srivastava et al (1963) show that a single female is capable of laying 300-400 eggs.

Table No. 2. Showing number of eggs laidby a single female during her life time.

S.No. of females.	Number of eggs.	Number of batches.	Average number of eggs per batch.
1.	117	39	3.0
2.	270	62	4.3
3.	165	33	5.0
4.	296	49	6.0
5.	244	61	4.0
6.	226	113	2.0
7.	120	60	2.0
8.	135	20	6.7
9.	306	102	3.0
10.	180	45	4.0
Average	205.8	58.4	4.0

There seems to be no fixed hour for egg laying as is evident from the fact that the eggs were laid any time in day hours or in the night in artificial light. However, a significant observation was that,during night hours, the eggs were laid in greater number (Table No. 3). Perhaps, the higher intensity of light of the electric bulbs stimulates egg laying.

Table No. 3. Showing number of eggs laid in 12 hours.

Serial No. of females.	Day 6 A.M. - 6 P.M.	Night 6 P.M. - 6 A.M.
1.	35	46
2.	46	67
3.	28	43
4.	30	83
5.	48	96
6.	43	71
7.	35	46
8.	38	48
9.	25	66
10.	52	77
Total No. eggs	380	640
Average No. of eggs	38	64

(vii) Pre-imaginal Stages.--

Egg Stage (Fig. 130).-- The mature egg is circular in outline, creamy white in colour with 0.62 mm in diameter. The chorion is thick and distinctly reticulate. The surface, by which the egg is attached to the substratum, is slightly flat. The colour of the egg changes to dark brown with the age of the egg. This change in colour is due to gradual appearance

of pigmentation on the embryo. This may be taken as an external indication to differentiate between normal healthy egg and undeveloped egg. The average incubation period at constant temperature and humidity (temperature, 29°C; R.H., 75 % ± 5%) was recorded to be 63 hours. The same period, in the field, was 80 hours (Table No.1). Srivastava et al (1963) show that the eggs hatch in 3-4 days.

The fully developed embryo, prior to hatching, was found exhibiting slight movement within the chorion. This was immediately followed by nibbling the chorion with the mandibles. This resulted in boring through the chorion and the larva pushed out its head through the hole and started wriggling movement to come out of the shell. The entire process of eclosion of the egg, on an average, took 37 minutes with maximum and minimum of 60 and 20 minutes, respectively (Table No.4).

The eggs exposed to hot and dry winds shrivelled and did not hatch. During the months of May and June, the eggs,laid under laboratory conditions, were transferred to the field by putting the potted Sann hemp plant there. The temperature and relative humidity ranged between 38°C and 45°C, and between 10% and 15%, respectively. These eggs did not hatch. They, on the other hand, developed a semi-spherical

depression on the upper surface which is a sign of drying up of the eggs.

Table No.4. Showing eclosion period.

S.No. of eggs.	Time of first movement inside the egg.	Time of exit of the larva from the egg shell.	Eclosion period.
1.	12.00 noon	12.30 p.m.	30 mts.
2.	11.55 a.m.	12.30 p.m.	35 mts.
3.	10.45 a.m.	11.20 a.m.	35 mts.
4.	11.20 a.m.	11.55 a.m.	35 mts.
5.	11.20 a.m.	12.20 p.m.	60 mts.
6.	11.50 a.m.	12.25 p.m.	35 mts.
7.	11.55 a.m.	12.40 p.m.	45 mts.
8.	12.30 p.m.	1.15 p.m.	45 mts.
9.	2.30 p.m.	3.00 p.m.	30 mts.
10.	2.50 p.m.	3.10 p.m.	20 mts.
		Average eclosion period	37 mts.

Larval Stage (Figs. 181, 182, 183, 184 & 185).-

The first instar larva is light orange in colour with the head and the protergum light brown and dark brown respectively. Small faint yellowish patches are found scattered on the thorax and abdomen. The entire body of the larva

is profusely setose. The presence of three pairs of jointed legs demarcates the thorax from the abdominal region. The latter possesses five pairs of prolegs on segments third to sixth and the tenth. There are nine pairs of spiracles located dorso-laterally on the prothorax and the first eight abdominal segments. The average body length of the first instar larva is 3.00 mm (Table No.5) and the average duration of the first stadium was 67 hours, whereas, in the field, the same period was recorded to be 78 hours (Table No.1).

Table No. 5. Showing average body length of the larval instars.

S.No.	Larval Instars	Average body length
1.	First instar larva	3.00 mm
2.	Second instar larva	4.02 mm
3.	Third instar larva	6.07 mm
4.	Fourth instar larva	11.05 mm
5.	Fifth instar larva	18.08 mm

The freshly hatched larva, soon after hatching, rested for a while before starting search of food. It moved widely including the walls of the rearing jar till it came in contact with the food. During this search, it did not hesitate in suspending itself with the help of silken threads. The larva never chewed the entire leaf. It fed only the

epidermal part of the leaf leaving the network of veins intact.

The second instar larva is similar to the first instar. Its average body length is 4.02 mm (Table No.5) and the duration of the second stadium was 49 hours. In the field, however, this duration was recorded to be 67 hours (Table No.1). The second instar larva fed on the epidermal, as well as, the cortical portion of the leaf.

The third instar larva develops white, narrow spots on its dorsum and a lateral greyish strip. Its average body length measures 6.07 mm (Table No.5). The duration of the third stadium in the laboratory and the field was 51 hours and 72 hours, respectively (Table No.1). Its feeding range increased over that of the second instar since it fed the entire leaf including the veins and the mid-rib.

The fourth instar larva abruptly changes to jet black in colourbut the white dorsal spots are retained. Its average body length shoots to 11.05 mm. (Table No.5). The duration of the fourth stadium was found to be 54 hours in the laboratory and 75 hours in the field (Table No.1). It was observed that the fourth instar larva, besides feeding on the leaf, also ate the developing young seeds by making its way into the pods. Normally, a pod was attacked by a single fourth instar larva but a maximum of three larvae were discovered from a single pod.

The fifth instar larva is also jet black in colour but its head becomes reddish brown. The mid-dorsal white spots alternate with orange spots. Similarly, the lateral greyish strip is flanked by a narrow orange strip. Its body length, on an average, measures 18.08 mm (Table No.8). The fifth stadium lasts for 81 hours in the laboratory and 92 hours in the field (Table No.1). The voracious fifth instar larva consumed all the parts of the food plant excepting the flower and the root. Because of its large size, it could not enter the pod completely.

The entire larval period took, on an average, 12 days and 14 hours under controlled conditions, whereas, in the field, it took 16 days. Srivastava et al (1963) record this period to vary between 11 and 20 days.

External Anatomy of the Fully Grown Larva

The fully grown larva (Fig.185) is cylinderical in shape. The trunk region consists of thirteen segments; the first three segments belong to the thorax, with a pair of thoracic legs each. There are five pairs of prolegs on the abdomen borne by the third to sixth and tenth segments. Nine pairs of spiracles are present on the terga; the first pair is located in the prothorax, while, the remaining eight pairs are in the first eight eight abdominal terga.

T H E H E A D (Figs. 185, 186 & 187).

The hypognathous, spherical head is antero-posteriorly flattened. Laterally, it bears six ocelli (O) arranged in such a manner that four of them form a semi-circle above the antennal socket (Asoc), while, the remaining two lie in a line close to the posterior mandibular articulation (a). The short antenna (Ant) is lodged in a big antennal socket flanking the mandibular base. The foramen magnum (For) is quite big with posterior tentorial pits (pt) in very close proximity with its lateral rim.

Sutures of the head capsule (Figs. 186, 187 & 190).—

Ecdysial cleavage line (Ecl).— It is a line of weakness along which the cuticle splits at the time of ecdysis. The ecdysial cleavage line extends as an inverted 'Y' shaped transparent band. The base of its stem runs across the top of the head to end on the dorsal portion of the postoccipital suture. The two divergent arms of the ecdysial cleavage line descend over the facial area to end on its ventral margin close to the anterior mandibular articulations.

Midcranial suture (MCS).— The midcranial suture is distinctly present, running mid-longitudinally on the stem of the ecdysial cleavage line. Internally, it is represented by a prominent ridge (MCR). Posteriorly, this suture extends upto the postoccipital suture, while, its anterior end meets the dorsally drawn out tip of the transfrontal suture.

Transfrontal suture (Tfs).-- The transfrontal suture is shaped like an inverted 'V' whose apex receives the anterior end of the midcranial suture. The two divergent arms of this suture end at the anterior tentorial pit. The entire suture is internally represented by a conspicuous ridge (TfR) and divides the frons into antefrons and postfrons.

Clypeogenal suture (CGS).-- There is a pair of clypeogenal sutures descending obliquely from the level of the frontal ganglion and extend upto the anterior mandibular articulation. These have clear internal inflections (CGR) and combiningly, limit the clypeus from the genae.

Transclypeal suture (TCS).-- The transclypeal suture runs across the face submarginal to the ventral margin and connects the two anterior mandibular articulations. Internally, it is represented by a corresponding ridge (TCR). It divides the clypeus into a narrow anteclypeus and a broad postclypeus.

There has been considerable controversy regarding the nature of the inverted 'V' shaped suture. Snodgrass (1947) and Short (1951) regard the arms of the inverted 'V' as the 'epistomal sulcus'. Hinton (1948) calls it 'adfrontal suture' and considers it to have developed to strengthen the head. LuPorte (1956,'57) in P.quinquemaculata terms the arm as the 'laterofacial suture' consisting of the'frontogenal'

and 'clypeogenal' sutures with anterior tentorial pits demarcating the two sutures. Recently, Zaka-ur-Rab (1964) in Papilio demoleus suggests that the upper halves of the arms combiningly be called as the 'transfrontal sulcus' and the lower halves as the 'clypeogenal sulci'. This view has been upheld here with the only difference that the clypeogenal suture of the larva of U. pulchella has been taken as a remnant of the laterofacial suture whose frontogenal part is wanting.

Postoccipital suture (Pos).— The submarginal postoccipital suture is present around the foramen magnum. It is internally represented by a prominent ridge. The ventral ends of the suture bear the posterior tentorial pits.

Hypostomal suture (hs).— It is distinct and extends from the posterior tentorial pit to the posterior mandibular articulation. Its corresponding internal ridge is well developed.

Areas of the head capsule (Figs. 186, 187 & 190).

Frons (Fr).— The frons is not separable either from the parietals of the clypeus due to the absence of the frontogenal and frontoclypeal sutures. It, can, however, be demarcated from the clypeus on the basis of the origin of paired

dilators of the pharynx and the median retractors of the labrum, as well as, on the location of the frontal ganglion at its border with the clypeus. The frontal ganglion (frGng) is, incidentally, situated at the level of the anterior tentorial pits and an imaginary line, connecting the pits, would separate the frons from the clypeus. The frons is divisible into the antefrons (AFrons) and the postfrons by the inverted 'V' shaped suture (transfrontal suture). Therefore, a narrow area (PFrons) dorsal and lateral to the transfrontal suture may be taken as the postfrons which is inseparable from the parietals.

Clypeus (Clp).— The clypeus is laterally demarcated from the parietals by the clypeogenal sutures, and, ventrally, from the labrum by the labral conjunctival membrane. Dorsally, the clypeus becomes contiguous with the antefrons and, thus, the median triangular area becomes the antefrons-cum-postclypeus (FrClp). The transclypeal suture divides the clypeus into a narrow anteclypeus (AClp) and a broad postclypeus (PClp).

In a lepidopterous larva (M. americana), Snodgrass (1947) names the median triangular sclerite, enclosed between the arms of the inverted 'V' shaped suture (his 'epistomal sulcus') as the clypeus. This interpretation of the

clypeus is based on the origin of the cibarial muscles attributed to it. Similarly, on myological grounds, and on the basis of the cleavage lines, the narrow sclerite,between the 'cleavage line' and the'epistomal sulcus', is defined by him as the'exposed part of the frons.'. Since, in U. pulchella, the third dilator of the pharynx arises outside the median triangular sclerite, this narrow band of sclerite beyond the transfrontal suture is definitely a part of the frons and is, consequently, named as postfrons. Similar stand has been taken by Zaka-ur-Rab (1964) in the larva of P. demoleus. DuPorte (1956,'57) considers the median triangular sclerite of the facial region as the'frontoclypeus'. The post-ganglionic pharyngeal dilator muscle (No.6) is taken by him to be an exception. DuPorte (1956) concludes, "While, therefore, the origin of the muscles is an important aid in determining the identity of sclerites, it is not an infallible one and due weight must be given to conflicting evidence from other sources". This quotation, evidently, does not lead to any implicit view which, at this stage of advancement in the study of facial area, is very essential.

Parietals (Prtl).— The parietal area is very extensive and anteriorly becomes contiguous with the postfrons due to the absence of the frontogenal suture. Posteriorly, it is limited by the combined postoccipital and hypostomal sutures. The true vertex appears to have disappeared because of the

unusual upward extensions of the frons and the foramen magnum. The genae (Ge) may be taken to be present as part of the parietals lateral to the clypeogenal sutures and containing the ocelli.

Hypostoma (Hst).-- It is present in the form of a subtriangular sclerite, laterally bounded by the hypostomal suture. The two hypostomal areas do not extend mesally to form the hypostomal bridge, a condition opposed to one reported by Eassa (1963) in the larva of Pieris brassicae.

Postocciput (Poc).-- It is a narrow, submarginal, sclerotic band around the lateral and dorsal parts of the foramen magnum. Dorsally, the postocciput is secondarily divided into two lateral halves because of a notch in the dorsal margin of the foramen magnum and the posterior extension of the midcranial suture.

Tentorium (Figs. 186, 190 & 192).-- The tentorium is poorly developed. It consists of paired, narrow, cylinderical and weakly sclerotised anterior (AT) and posterior (PT) tentorial arms, with their bases in the anterior (at) and the posterior (pt) tentorial pits, respectively. The anterior tentorial arms run obliquely backwards to fuse with the posterior tentorial arms. The dorsal tentorial arms are wanting.

Antenna (Figs. 186, 188 & 190).-- The short antenna (Ant) consists of two segments. The basal segment (Sc) is comparable

with the scape. It is lodged in a prominent socket (Asoc) with extensive suspensorial membrane suspending it from the rim of the socket. It receives a muscle from the cranium. The second segment (Pe) can be taken as the apical segment. It is devoid of muscles. Its tip is membranous with setae(sta) arising from it.

Retractor of the antenna (Figs. 188 & 190; No. 161).— The retractor muscle originates on the gena and close to the anterior tentorial pit. Its parallel fibres descend obliquely to get inserted on the dorsal half of the proximal rim of basal segment. On contraction, the muscle retracts the antenna into the antennal socket. Bassa (1963) in P. brassicae reports a similar 'antennal muscle' and assigns it with similar function. Srivastava and Mathur (1964) in P. litura record a pair each of 'extensor' and 'flexor' muscles arising on the anterior tentorial arm and inserting 'within the scape'; but their Fig. No. 12, shows these muscles inserted on the rim of the'pedicel'.

Labrum (Figs. 186, 190 & 196).— The labrum (Lm) is a broad flap like structure suspended from the ventral margin of the anteclypeus by a wide membrane. It hangs over the food meatus. The lateral angles of the labral epipharynx (Ephy) bear short tormae (Tor) for the insertion of the retractor muscles. The movements of the labrum are controlled by the following muscles.

Median retractor of the labrum (Figs. 190 & 196; NO. 162).— It originates on the antefrons close to its apex. The muscle descends to get inserted on the middle of the proximal margin of epipharynx. The contraction of this muscle retracts the labrum. It is similar to the 'inner retractor of the labrum' of P. quinquemaculata (DuPorte, 1956) and the 'median retractor of the labrum' of P. demoleus (Zaka-ur-Reb, 1964). Srivastava and Mathur (1964) in P. litura name a similar muscle as 'anterior palatal muscle' but do not assign any function to it.

Lateral retractor of the labrum (Figs. 190 & 196; No. 163).— This large muscle arises on the dorsal half of the mideranial ridge and descends in a slightly divergent manner to get inserted on the torma. On contraction, it also retracts the labrum. A similar muscle has been reported by DuPorte (1956) in P. quinquemaculata, Eassa (1963) in P. brassicae and Zaka-ur-Reb (1964) in P. demoleus. Srivastava and Mathur (1964) call such a muscle as 'lateral labral muscle' but again do not assign any function to it.

Mandible (Figs. 186, 189 & 190).— The mandibles (Md) are highly sclerotic structures with their broad base articulated to the ventro-lateral margin of the cranium. The anterior basal angle of the mandible bears a concavity (c) which receives the corresponding condyle of the cranium, whereas, the posterior basal angle (a) is modified into a distinct condyle to articulate with the corresponding concavity of the cranium. From the base of the

mandible and close to its angles arise anterior (Adap) and posterior (Abap) apodemes for the insertion of the muscles. The distal margin of the mandible is dentated (d). The outer surface is smooth and convex while the inner one is concave and provided with curved ridges (mr) extending from inter-dental grooves. The following muscles impart the movements of adduction and abduction to the mandibles.

Adductor of the mandible (Fig. 190; No. 164).— It is a massive muscle whose fibres arise from the entire lateral area of the cranium. These fibres end on the anterior apodeme. On contraction, the muscle moves the mandible inwards.

Abductor of the mandible (Fig. 190; No. 165).— This is a relatively smaller muscle which originates on the gena. Its fibres end on the posterior apodeme. Functionally, it is antagonistic to the adductor muscle.

Maxillo-labial-hypopharyngeal complex.— The maxillae, the labium and the hypopharynx are united to form a composite structure, called maxillo-labial-hypopharyngeal complex. The latter becomes the underlip of the catterpillar. The maxillae are basally articulated to the hypostoma. The basal portion of the labium provides attachment to the neck membrane, while, the apical portion in conjunction with the hypopharynx, forms the spinning apparatus.

Maxilla (Figs. 187, 191 & 193).— The maxilla (Mx) can be distinguished from the labium and hypopharynx by its position. It is

divisible into three parts, viz., the cardo (Cd), stipes (St) and the terminal lobe (Lo); the latter bearing the maxillary palp (MxPlp) and the galea (Ga). The cardo is a small, more or less, 'C' shaped sclerotic plate whose convex margin possesses a distinct articular knob (a") to articulate with the corresponding articular concavity of the hypostoma. The stipes is a big sclerotic plate which has secondarily become membranous in its middle. Mesally, it bears the prominent stipital ridge (q) which forms its mesal limit. The apex of the ridge (r) fits into the side of the prementum and serves as fulcrum for the spinning apparatus. The terminal lobe is mostly membranous with islands of sclerites called basal (BP) and apical (AP) plates. The apex of the terminal lobe is membranous and bears two small sclerotic plates. The mesal plate forms the galea (Ga) while the outer one is the two segmented maxillary palp (MxPlp) as discovered by Eassa (1953) in his study on the embryology of P. brassicae.

Muscles of the maxilla.

Adductors of the cardo (Fig. 192; Nos. 166 & 167).— There are two such muscles which arise on the posterior tentorial arm. Running posteriorly, the two muscles cross each other to get inserted on the cardo. In P. brassicae, Eassa (1963) shows only one 'adductor muscle', whereas, in P. litura, Srivastava and Mathur (1964) record two such muscles.

Adductors of the stipes (Fig. 192; Nos. 168 & 169).— The two adductors of the stipes originate on the anterior tentorial arm. These descend posteriorly to end on the basal half of the

stipital ridge. Eassa (1963) in P.brassicae and Srivastava and Mathur (1964) in P.litura have also shown two such muscles.

Flexor of the stipes (Fig. 192; No. 170).— It is a broad muscle which arises on the postfrons close to the arm of the ecdysial cleavage line. Descending obliquely and flanking the anterior tentorial arm, it ends on the apical half of the stipital ridge. It may be compared with the 'cranial flexor of the stipes' of P.litura (Srivastava and Mathur, 1964).

Retractors of the terminal lobe (Fig. 193; Nos. 171, 172 & 173). There are three retractor muscles. Two of them (Nos. 171 & 172) originate on the basal tip of the stipital ridge and, descending along almost parallel course, these end on the basal angles of the basal plate. The third retractor muscle (No. 173) arises in the ventral angle of hypostoma. It descends mesally directed and, crossing the second retractor muscle (No. 172), ends on the basal plate in close proximity to the first retractor muscle. The first two retractors are similar to the 'external' and 'internal' retractors of the'free lobe' of P.brassicae (Eassa,1963).

Labium and hypopharynx (Figs. 191, 194 & 196).— The labium is divisible into the postmentum (Pmt) and the prementum (Prmt). The former is largely membranous excepting two small sclerites, flanked by the cardines. The prementum consists of a large 'U' shaped sclerite (Prmta) and a narrow sclerotic band (Prmtb) forming a ventro-lateral collar for the spinneret and the labial palp. The 'U' shaped portion of the prementum contains a pair of small

concavities in the middle of its arms for articulation of the stipital ridges. Distally, the prementum bears a short one segmented labial palps(LbPlp) and a median, hollow spinneret (Sr); the latter is traversed along its entire length by the terminal duct of the 'silk press'. Anteriorly, the prementum bears the oblong shaped membranous hypopharynx (Hphy). The prementum-cum-hypopharynx forms the spinning apparatus of the larva of U.pulchella. Within the spinning apparatus is lodged the silk press (SP) which is the modified salivarium. The dorsal wall of the silk press is concave with distinct sclerotisation in its middle which is comparable with the 'raphe' (Rph) of the silk press of catterpillars.

Muscles of the spinning apparatus.— The muscles of the labium are responsible for the movement of the spinning apparatus. There are two pairs of such muscles. The silk press is also controlled by two pairs of muscles. A coordinated action of these four pairs of muscles is responsible for spinning of the cocoon.

Levator of the spinning apparatus (Fig. 195; No. 174).— It is a long muscle. Arising on the anterior tentorial arm, the muscle descends obliquely to end on the base of the hypopharynx. A similar muscle has been named as 'productor of the spinning organ' by Eassa (1963) in P.brassicae.

Depressor of the spinning apparatus (Fig. 195; No. 175).— The origin of this muscle lies on the posterior tentorial arm. It

dives to end on the basal margin of the 'U' shaped portion of the prementum. An identical muscle has been named as 'reductor of the spinning organ' by Eassa (1963) in P.brassicae.

The two muscles alternately act to raise and lower the spinning apparatus. Such movements in rapid succession enable the larva to levate and depress the spinneret as well.

Dorsal dilator of the silk press (Fig. 195; No. 176).— It is a long muscle, which, arising on the distal half of the arm of prementum, descends obliquely to end on the raphe. Eassa (1963) in P.brassicae shows two such muscles.

Lateral dilator of the silk press (Fig. 195; No. 177).— This short muscle originates,laterally, on the proximal half of the arm of prementum. It is inserted on the raphe lateral to the dorsal dilator. It is similar to the 'ventral muscle of the silk press' of P.brassicae (Eassa, 1963).

The above two dilators pull up the raphe which changes its position from invagination to evagination. This allows flow of saliva from the salivary duct into the salivarium. The relaxation of the dilators enable the elasticity of the raphe to come into play, thereby, restoring invaginated condition to the raphe.

The cibarium (Fig. 196).— The cibarium (cb) is the preoral cavity lying anterior to the frontal ganglion (frGng). It is bounded anteriorly by the epipharyngeal wall of the clypeus, laterally by

the bases of the mandibles and posteriorly by the hypopharynx. It is controlled by the following muscles.

First dilator of the cibarium (Figs.186 & 196; No.178).-- It is a short muscle arising on the transclypeal ridge. The muscle diverges to get inserted on the roof of the cibarium on its antero-lateral portion. It is similar to the 'dorsal dilator of the cibarium, No. 1' of P.quinquemaculata (DuPorte, 1956) and the 'antero-lateral dilator of the cibarium' of P.demoleus (Zaka-ur-Rab, 1964).

Second dilator of the cibarium (Figs. 186 & 196; No. 179).-- This muscle is stouter than the first dilator. Arising laterally on the postclypeus,close to the middle of the clypeogenal suture, it ends on the postero-lateral portion of the cibarial roof. It is similar to the 'dorsal dilator of cibarium, No. 2' of P.quinquemaculata (DuPorte, 1956). Zaka-ur-Rab (1964) shows this muscle to be made up of two or three bundles and calls it 'postero-medial dilator of cibarium'.

Third dilator of cibarium (Figs. 186 & 196; No. 180).-- It is identical to the second dilator of the cibarium and arises on the postclypeus between the origin of the second dilator of the cibarium and the anterior tentorial pit. Descending obliquely, it ends on the postero- lateral portion of the cibarial roof. It resembles the 'dorsal dilator of cibarium, No.3' of P.quinquemaculata (DuPorte, 1956).

The cephalic stomodaeum (Fig. 196).-- The portion of the stomodaeum within the head and posterior to the frontal ganglion (frGng) is the pharynx (Phy). It is connected with the ciberium through the true mouth.

First dilator of the pharynx (Figs. 186 & 196; No. 181).-- This muscle takes its origin on the antefrons. Descending almost horizontally, it gets inserted on the roof of the pharynx, posterior to the frontal ganglion, flanked by its connectives. It is comparable with the 'dorsal dilator of pharynx, No. 4' of P.quinquemaculata (DuPorte, 1956).

Second dilator of the pharynx (Figs. 186 & 196; No. 182).-- It is similar to the first dilator muscle but arises posterior to it and slightly mesal to the transfrontal ridge. Its insertion on the pharynx is slightly lateral to the first dilator. This muscle may be compared with the 'dorsal dilator of pharynx, No. 5' of P.quinquemaculata (DuPorte, 1956) and the 'antero-median dilator of the stomodaeum' of P.demoleus (Zaka-ur-Rab, 1964).

Third dilator of the pharynx (Figs. 186 & 196; No.183).-- This stout muscle originates on the parietal area slightly lateral to the ecdysial cleavage line . Descending obliquely, it is inserted on the pharyngeal roof, close to the insertion of the second dilator of the pharynx. It resembles the 'dorsal dilator of pharynx, No. 6' of P.quinquemaculata (DuPorte, 1956) and the 'postero-lateral dilator of the stomodaeum' of P.demoleus (Zaka-ur-Rab, 1964).

THE THORAX (Fig.185).

The thorax is distinctly divisible into three segments, the prothorax, the mesothorax and the metathorax. Each segment bears a pair of legs. The dorsum, pleura and the venter are extensively membranous with secondary sclerotisation confined to the first two surfaces. The pleuron is demarcated from the dorsum by a conspicuous longitudinal fold, called 'dorsopleural line', whereas, the corresponding pleurosternal line is not traceable which means complete continuity of the venter with the pleura.

The prothorax (TI) is separated from the head by the intervention of wide membranous cervical region. There is no cervical sclerite to establish sclerotic articulation of the thorax with the head. The prothoracic dorsum possesses ~~spir~~ a pair of large (TT1) and another pair of small (VT1) tergites. The dorsal pair of tergites (TT1) bears four pairs of long stout setae defining the four angles of the plates. The small ventral tergites (VT1), having one seta on each plate, are slightly dorsal to the first thoracic spiracles(Sp1).

The meso- and metathorax (TII and TIII) are exactly identical to each other. Each dorsum contains two pairs of dorsal tergites (TT1 & TT2) and another two pairs of ventral tergites (VT1 & VT2). The dorsal tergites (TT) possess one stout seta on each plate. The anterior tergites of the ventral pair (VT1) bear two setae each, while, each of the posterior tergites (VT2) contains only one seta.

The pleura of the thorax are entirely membranous with a pair of sclerotic pleurites (tp) lying between the dorsopleural line (dl) of each segment and the leg-bases. A pair of stout setae are borne on each plate. The leg-bases are completely membranous with no sclerotic articulation of the coxae.

The legs (Fig. 197).-- The three pairs of thoracic legs are identical. Each leg consists of the usual six sclerotic segments, viz., coxa, trochanter, femur, tibia, tarsus and the pretarsus. The coxo-trochanteral, femoro-tibial, tibio-tarsal and tarso-pretarsal joints are monocondylic. The well developed coxa (Cx) is suspended from the latero-ventral portion of the segment through distinct conjunctiva. The outer wall of the coxa is traversed by a distinct coxal suture (Cs) extending from the base of the anterior trochanteral articulation to its proximal rim(Cxpr). The trochanter (Tr) is a narrow ring like segment. The anterior half of its proximal rim has developed a distinct concavity (b) to provide articulation to the corresponding articular knob of the coxa (b'). The distal rim of the trochanter is plain and devoid of sclerotic articulation with the femur. This confirms absence of trochantero-femoral articulation. The femur (Fm) is large and cylinderical. Its outer angle (i') is modified into an articular knob to articulate with the corresponding concavity (i) in the proximal rim of tibia. The cylinderical tibia (Tb) is shorter than the femur. The outer angle of its distal rim (j') bears an articular knob for

articulation with a corresponding concavity (j) in the proximal rim of the tarsus. The conical tarsus (Tar) is proximally broad and distally narrow. The pretarsus (Ptar) is represented by an unpaired stout sclerotic claw. The base of the claw possesses a small concavity (m). This provides articulation to the articular knob borne in the middle of the lateral half of the distal rim of tarsus (m').

THE ABDOMEN (Fig. 135).

The abdomen consists of ten distinct segments connected with each other by a very narrow stretch of intersegmental membrane. The first eight segments (I3-8) are nearly equal in size, while, the last two segments (9-10) are comparatively shorter. The dorsum, pleura and venter are completely membranous with secondary sclerotisation of the dorsum and pleura. The dorsopleural line (a'b) is represented by a very faint groove on the abdomen. It is, however, not traceable posterior to the middle of the ninth segment. The eight pairs of spiracles are located on the sides of the first eight abdominal segments slightly above the dorsopleural lines.

The dorsum of the abdomen is extensively membranous with islands of tergites. These tergites, in the first eight segments, are arranged in two rows; each row containing four tergites. The rows, on the basis of their comparative positions, can be taken as anterior and posterior rows. The dorsal tergites

of the anterior row (m) and all the tergites of the posterior row (n,p) bear a single stout seta on each plate. The ventral tergites of the anterior row (o) are provided with two long setae each. Further, these tergites are located antero-dorsal to the spiracles excepting the second abdominal segment, where, these plates are are distinctly dorsal to the spiracles. The dorsum of the ninth segment ((9S) has only one pair of laterally placed tergites (l) with three stout setae on each. The tenth dorsum contains an unpaired tergite (t) bearing six setae.

The pleurites have interesting arrangements in segments one to nine (1S - 9S), while, the tenth segment (10 S) is devoid of pleurites. In the first two abdominal segments, each pleuron contains four pleurites of varying size, arranged in a dorso-ventrally directed row. The first and second dorsals (e,f) and the first ventral (h) pleurites bear a stout seta each, whereas, the second ventral (g) possesses three long setae. In the leg bearing segments (third to sixth) the two dorsals (e,f) are retained, whereas, the two ventrals are lost. The relative position of the dorsals (e,f) gradually changes from exactly dorso-ventral to obliquely dorso-posterior position. The first dorsal (e) contains the usual single seta, while, the second dorsal (f) bears two stout setae. In the seventh and eighth segments (7 S and 8 S), the two dorsals (e,f) have assumed antero-posterior arrangement with a seta on each, whereas, the two ventrals (h,g) repeat the arrangement of the first

abdominal segment. The first ventral (h) bears only one long seta, while, the second one (g) possesses two such setae. In the ninth segment (9 S), the first dorsal pleurite is wanting. The second dorsal pleurite (f), containing two setae, has moved up to lie close to the dorsopleural line (a'b). The two ventral pleurites (h,g),with their setae, are similar to those of the eighth segment, but their respective placing is obliquely dorso-ventral. The pleural region of the tenth segment (10 S) is devoid of the pleurites and stout setae.

The prolegs (Figs. 185 & 198).-- The segments three to six and tenth bear a pair of prolegs each. All the five pairs of prolegs(PL) are identical in anatomy. Each proleg consists of three segments. The basal segment (fMB), called 'flexible integument', is completely membranous and works as suspensorium for the proleg to give suspension to it from the abdomen. The middle segment (Cxb) of the proleg is large and subcylinderical with its lateral area distinctly sclerotised. The apical small segment (Pln) is called the'planta'. It is separated from the preceding segment by a narrow stretch of membrane. The planta is semi-sclerotised and retractile. It is almost semi-circular in shape with a row of about 12 curved, strongly sclerotised crochets (Ct), arranged on its mesally directed periphery. The number of the crochets, in the last proleg, is reduced to about eight. Besides,crochets, there is a variable number of short, comparatively weak and curved spines (Sn) also on the planta.

The Dyar's Law (TableNos. 6 & 7)

During the course of investigations on the life-history of U.pulchella, the present writer felt the necessity of confirming the exact number of instars by applying the Dyar's Law to its larval stages. For this purpose, the head widths of ten larvae of each instar were measured and their means were calculated (Table No. 6). By dividing each observed width by the width of the head of the preceding instar, the ratio of increase in each instar was determined. The average of such ratios came to 1.48. The approximation between the observed and calculated head widths of the instars is so close that there was no possibility of any instar being overlooked. This shows that the Dyar's Law is applicable on the larvae of U.pulchella (Table Nos. 6 & 7).

The Dyar's Law has been successfully applied to the larvae of Lepidoptera (Plutella maculipennis C.) by Beri (1961). Mayers and Babers (1944) are doubtful about its use in Prodenia eridania Cr. Qadri (1938) has found it working well upto the third nymphal instar of Blatta orientalis L., (Orthoptera). Akbar (1958) in L.varicornis (Hemiptera) and Alam (1952, '57) in S.deesae and Metaphycus taxi Alam (Braconidae and Encyrtidae) have successfully applied the Dyar's Law to their respective insects. Recently, Arora

(1959) has shown the application of Dyar's Law on the larval stages of Diprion nini L., (Diprionidae).

Table No. 6. Showing average head width and "Mean S.D."

Larval instars	Mean (of ten head widths)	S.D.
1st instar	0.342 mm	0.0038
2nd instar	0.454 mm	0.0047
3rd instar	0.680 mm	0.0047
4th instar	1.142 mm	0.0034
5th instar	1.633 mm	0.0059

Table No. 7. Showing application of Dyar's Law.

Larval instars	Calculated width of head.	Measured width of head.
1st iinstar	= 0.342 mm	0.342 mm
2nd instar	(0.342 x 1.48) = 0.506 mm	0.458 mm
3rd instar	(0.506 x 1.48) = 0.749 mm	0.680 mm
4th instar	(0.749 x 1.48) = 1.108 mm	1.142 mm
5th instar	(1.108 x 1.48) = 1.639 mm	1.633 mm

Food selection behaviour of the fully grown larva

During the course of investigations on the life-history of U. pulchella, it was revealed that the larvae also feed on Heliotropium indicum L., H. Eichwaldi Steud., and Trichodesma indicum R. Br. This observation amounts to confirmation of the report of Singh (1941) who recorded these plants as hosts of U. pulchella. The scattered knowledge on the food plants of U. pulchella inspired the present writer to trace out the range of food plants and the preferential behaviour, if any, of the larvae to these plants. Accordingly, ten plants (seven belonging to the family Leguminosae and three to Boraginaceae) were selected, which are easily available in Aligarh and its surroundings. The following experiments were conducted in the laboratory at 29° C and relative humidity 75% ±5%.

First experiment (Graph I).—

In the first experiment, ten different kinds of plant leaves belonging to the families Leguminosae and Boraginaceae were selected. The plant leaves of each type, weighing 5 gms., each were placed in ten glass jars (8"x4") with their open ends covered with muslin cloth. One hundred larvae of fifth instar, bred in the laboratory, were starved for 24 hours before being released equally (10 larvae each) in ten jars. After every four hours, the remaining leaves were weighed and were replaced by fresh stock of 5 gms., leaves in each jar. The experiment lasted for 24 hours (Table No. 8). The total weight of the

leaves eaten showed that the larvae feed, in order of preference, only on Crotolaria juncea L., Heliotropium indicum and Trichodesma indicum; the remaining seven plants were totally neglected.

Table No. 8.

S.No.	Name of the plant used as food	Total weight of the leaves consumed by 20 larvae in 24 hours.
1.	Dolichos lablab L. (Bean)	nil
2.	Pisum sativum L. (Pea)	nil
3.	Crotolaria juncea L. (Sann hemp)	24.8 gms.
4.	Phaseolus radiatus L. (Moong)	nil
5.	Cicer arietinum L. (Gram)	nil
6.	Cajanus cajan Millsp. (Arhar)	nil
7.	Trigonella Foenum-graecum (Methi)	nil
8.	Heliotropium indicum L.	16.2 gms.
9.	Heliotropium eichwaldi Steud.	1.8 gms.
10.	Trichodesma indicum R.Br.	14.0 gms.

Second experiment.—

This experiment was made with a view to record the preference of food by confronting the larvae with fancied and despised foods, simultaneously. The experiment was carried out in three stages. A glass trough of 15" diameter was selected and its bottom was divided into six equal sectors to facilitate the placing of the leaves equidistant from the centre. The mouth

of the trough was covered with a muslin cloth.

First stage (Graph II).— In this experiment, equal quantities of six types of leaves (C. juncea, T. indicum, H. indicum, D. lablab, C. cajan and P. sativum) were placed on the periphery of the marked sectors in such a way that the preferred foods alternate with the despised ones (Table No. 9a). Twenty starved larvae were released in the centre of the trough to make their own selection of food. The experiment lasted for eight hours. The results (Table No. 9b) show that the larvae feed, in order of preference, on C. juncea, H. indicum and T. indicum.

Table No. 9a. Showing arrangement of the leaves in the first stage.

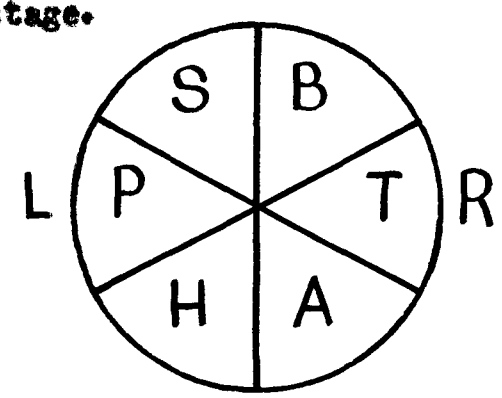


Table No. 9b.

S.No.	Types of plant leaves.	Total weight consumed during eight hours.
1.	C. juncea (S)	10.8 gms.
2.	D. lablab (B)	nil
3.	T. indicum (T)	4.4 gms.
4.	C. cajan (A)	nil
5.	H. indicum (H)	6.8 gms.
6.	P. sativum (P)	nil

Second stage (Graph III).— This experiment differed from the first stage experiment in the placing of the leaves; other conditions remained to be the same. The leaves were so arranged in the sectors that the three adjoining sectors, on the left side, contained the fancied foods, while, the despised foods occupied the remaining three sectors of the right side (Table No. 10a). The observations were recorded after eight hours. The results show that C. juncea leaves were preferred over those of H. indicum and T. indicum (Table No. 10b).

Table No. 10a. Showing arrangement of the leaves in the second stage.

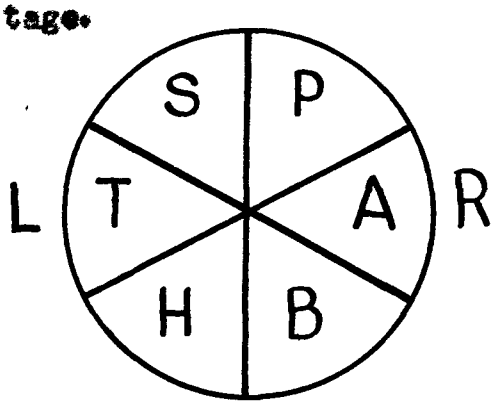


Table No. 10b.

S. No.	Types of plant leaves.	Total weight consumed during eight hours.
1.	C. juncea (S)	13.4 gms.
2.	T. indicum (T)	5.0 gms.
3.	H. indicum (H)	7.8 gms.
4.	D. lablab (B)	nil
5.	C. cajan (A)	nil
6.	P. sativum (P)	nil

Third stage (Graph IV).-- This experiment was also conducted on the lines of the previous two experiments with the only difference that,here, the leaves of fancied plants were arranged in the three adjoining sectors on the right side of the trough, whereas, the despised foods were kept in the remaining three sectors on the left side (Table No. 11a). The observations, when recorded after eight hours, show that the change of sides did not affect the preferemce of food by the larvae (Table No.11b).

Table No. 11a. Showing arrangement of the leaves in the third stage.

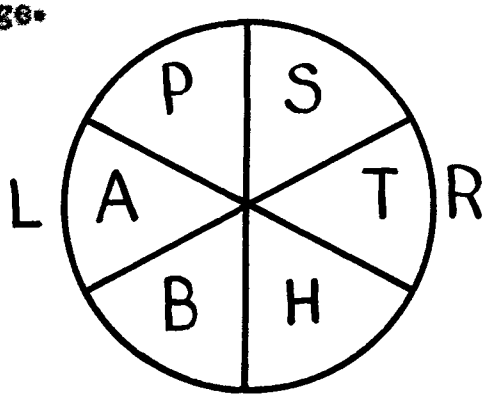


Table No. 11b.

S. No.	Types of plant leaves.		Total weight consumed during eight hours.
1.	P. sativum	(P)	nil
2.	C. cajan	(A)	nil
3.	D. lablab	(B)	nil
4.	H. indicum	(H)	10.6 gms.
5.	T. indicum	(T)	6.8 gms.
6.	C. juncea	(S)	12.9 gms.

Keeping in view the entire set of experiments, it can be concluded that C. juncea is best preferred as food by the fully grown larva of U. pulchella. Its next best choice of food lies in H. indicum, whereas, T. indicum is placed third in order of preference of food.

Cannibalism — During the course of investigations on the life-history of U. pulchella, it was observed that a few of the mature larvae were missing from the rearing jars and still others were lying dead or half dead with their dorsum eaten off. At first it was taken for some bacterial infection but on careful examination it was suspected for a case of cannibalism under starvation. With a view to ascertain it, the following experiments were set up.

Experiment I. In this experiment, 10 fully grown larvae, starved for 12 hours, were released in 10 rearing jars. Each jar also contained 5 fully fed larvae of each instar. There was no host plant in the jars. It was observed that, during a period of 4 hours, the starved larva attacked a fifth instar larva by piercing its mandibles into the abdominal dorsum of the latter. The fully fed larva tried to run away but the attacking larva did not leave it, and started gnawing the terga and the prey ultimately succumbed to the attack. Such attack was performed by all ten larvae under observation.

Experiment II. This experiment was designed to find out the presence of cannibalism in the presence of ample food. For this purpose, another set of 10 fully grown larvae was starved for 12 hours. These were put in 10 rearing jars containing host plant

as well as, 5 full fed larvae of each instar. It was found that the starved larvae fed on the host plant ignoring the larvae.

Experiment III. This experiment was conducted in two stages. In the first stage, 10 fully grown larvae were allowed to enact cannibalism in a manner recorded in the first experiment. In the second stage , these cannibals were released in 10 rearing jars containing 5 larvae of each instar and the host plant. It was observed that in six cases, the cannibals straightway started feeding on the host plant and totally ignored the other larvae. In two other cases, the cannibals did attack the other larvae but soon switched on to feeding on host plant, and never repeated any attack on the larvae. In the remaining two cases, the cannibals started feeding on the host plant but they also attacked other larvae with whom they came in contact during the process of feeding.

Taking into consideration the experiments on cannibalism, it can be suggested that the fully grown larvae (fifth instar) of U. pulchella, under normal conditions, instinctively feed on the host plant. Further, they are not prepared to change over from phytophagous/to entomophagous/mode of feeding. Nevertheless, it has been revealed that, under forced conditions, the larvae of U. pulchella can conveniently resort to cannibalism confining the attack on the fifth stage larvae only. It can further, be inferred that a cannibal takes no time to return to its natural phytophagous habit on the availability of the host plant. However,

the very fact that a strictly phytophagous insect can resort to cannibalism has been exhibited by the fifth instar larvae of U. pulchella and this is a unique addition in the behaviour of phytophagous insects.

Pupal Stage (Fig. 199).— The pupation took place, either on the ground or in folded leaves. Before entering into the pupal stage the mature larva stopped feeding and started spinning a thin silken cocoon. The walls of the cocoon were sparsely embedded with foreign bodies. After the completion of the cocoon, it got shrunk and quiescent. The inactive larval condition continued for about 25 hours. Synchronising with the end of this period, the larva discharged some greenish material through anus. Such discharge of faecal matter has been reported by Alam (1952, '57) in E. daesa and M. taxi. This was followed by casting off the last larval moult, which was, later on, discovered from the cocoon. The larva had now completely changed into a newly formed pupa of creamy white colour. This colour changed into dark brown and the pupa now became the 'obtect type'. The average pupal period was recorded to be 123 hours (Table No. 1). The observations in the field showed that the pupal period lasted for 144 hours.

(viii) Emergence of the Adult.

The behaviour of emergence commenced with the swelling of the body, which should be attributed to engulfing of air by the pupa, thereby, applying pressure on the enclosing puparium. As a result of this pressure, longitudinal splitting of the puparium took place along its inter-appendicular portions. This

was followed by disengagement of legs, antennae and the proboscis from the puparium. Such disengagement left a big hole on the ventral surface of the proximal half of the puparium. This hole was, ultimately, utilised by the adult to come out of the puparium through it. Soon after emergence, the moth excreted a few drops of a thick dark brown fluid through the anus. It, then, rested for about an hour on the spot in almost vertical position. During this period, the wings gradually expanded to their normal size, thereby, enabling the adult to fly away. In rare cases, it was observed that the wings of freshly emerged moths could not attain the normal size. Such moths, unable to fly, were found hopping on the substratum. This abnormality in the wings, however, did not interfere with the normal activities of the moths.

(ix) Longevity and Sex ratio.—

The males of U. pulchella are short lived and die, on an average, after 5 days without food (Table No. 12B) and after 9 days on normal food (Table No. 12A). The average longevity of the females, on the other hand, is of 6 days without food (Table No. 12B) and of 10 days on normal food (Table No. 12A). In a few cases, the feeding females could survive for about 15 days.

The study of sex ratio, based on emerged adults, was made under laboratory conditions. It shows that the females outnumber the males and their ratio comes to 100:71 (Table No. 13).

Table No. 13. Sex ratio of adults emerged under laboratory conditions.

No. of Pupae under observation.	No. of emerged males.	No. of emerged females.
95	33	62
91	38	53
88	28	60
90	43	47
78	40	38
91	24	67
58	30	28
89	29	60
87	51	36
88	39	49
Total 855	355	500

Ratio of Female : Male = 100 : 71

6. REFERENCES

1. Akbar, S.S. 1957. The morphology and life-history of Leptocorisa varicornis F. (Coreidae, Hemiptera)— a pest of paddy crop in India. Part I. Head and thorax. Alig. Musl. Univ. Publ. (Zool.Ser.) Ind. Ins. Typ., 5 (1) : 53 pp.

2. " 1958. The morphology and life-history of Leptocorisa varicornis F. (Coreidae, Hemiptera)— a pest of paddy crop in India. Part II. Abdomen, internal anatomy and life-history. Ibid.5(2):49pp

3. Alam, S.M. 1951. The skeleto-muscular mechanism of Stenobracon deesae Cam. (Braconidae, Hymenoptera) an ectoparasite of sugarcane and juar borers of India. Part I. Head and thorax. Ibid.,3(1):74pp.

4. " 1952. A contribution to the biology of Stenobracon deesae Cam. (Braconidae, Hymenoptera) and the anatomy of its pre-imaginal stages. Parasitenk. 15 : 159-182.

5. " 1952. Male Genitalia in Stenobracon deesae C (Braconidae, Hymenoptera), Beitr. Ent., 2:621-635

6. " 1953. The skeleto-muscular mechanism of Stenobracon deesae Cam. (Braconidae, Hymenoptera an ectoparasite of sugarcane and juar borers of India. Part II. Abdomen and internal anatomy. Alig. Musl. Univ. Publ. (Zool.Ser.) Ind.Ins.Typ. 3(2) : 75 pp.

7. Alam, S.M. 1957. The biology of Metaphycus taxi Alam (Encyrtidae, Hymenoptera) in the constant temperature room, with notes on the anatomy of its pre-imaginal stages. Ind.Journ.Ent. 19 (4) : 231-240.

8. " 1958. Life-cycle and host-parasite relationship in the field and the larval anatomy of Metaphycus taxi Alam. Proc.Tenth Internl. Congr.Ent. 4 : 879-887.

9. " 1960. Some suggestions on the morphology of termites: Symposium: Termites in humid tropics. Organisers, Unesco & Zoological Survey India: 63-65.

10. " 1965. Review on the knowledge of morphology of Indian insects during the last 25 years. Entomology in India, II, Entomological Society of India (in Press).

11. Albrecht, F.O. 1953. The anatomy of migratory locust. The Athlone Press, University of London : 118 pp.

12. Allman, S. 1930. Studies on the anatomy and histology of the female reproductive system of the Codling moth, Carpocapsa pomonella L. Univ. Calif. Press Publ. 5 : 135-165.

13. Arora, G.L. 1959. External morphology of the larva of Dirrion pini L. (Symphyta:Hymen.) Res. Bull. E.Punjab Univ. Hoshiarpur.Zool.10(1) : 55-64.

14. Ayyar, T.V.R. 1940. Handbook of Economic Entomology for South India, Govt.Press,Madras, 528 pp.

15. Beard, R.L. 1953. Insect Physiology,(Edited by K.D. Roeder) John Wiley & Sons Inc. New York :232-272.

16. Beckel, W.E. 1956. The morphology, histology and physiology of the spiracular regulatory apparatus of Hyalophora cecropia (Lepidoptera).Proc. Tenth Internl.Congr.Ent.Montreal.2: 85-115.

17. Beri, Y.P. 1961. Studies on the application of Dyar's Law to the larval stages of Plutella maculipennis Curtis. Ind.Journ.Ent.23(1) : 69-70.

18. Bhattacharya, N.S. & Ramdas Menon, M.G. 1964. Bionomics, biology and control of Hymenia recurvalis F. (Pyralidae:Lepidoptera).Ind. Journ. Ent. 26 (2) : 176-183.

19. Bickley, W.E. 1942. On the stomodaeal nervous system of Insects. Ann.ent.Soc. Amer.35(3):343-354.

20. Bigelow, R.S. 1954. Morphology of the face in Hymenoptera. Canad.Journ.Zool. 32 : 378-392.

21. *Bourgogne, J. 1951. Traite de Zoologie. 10 (I): 174 Paris, Masson.

22. Burgess, E. 1880. Contributions to the history of the milkweed butterfly Danias archinnus F. Anniv. Mem.Boston Soc. Nat. Hist : 1-16.

23. " 1880. The structure and action of the butterfly's trunk. Amer.Nat.14(5) : 313 p.

31ag* Comstock, J.H. 1918. The wings of insects. The Comstock Publishing Company, Ithaca : 430 pp.

24. *Burmeister, H. 1832. Handbuch der Entomologie, I. Berlin : G.Reimer.

25. Buxton, P.A. 1931. The measurement and control of atmospheric humidity in relation to Entomological problems. Bull.ent.Res.22:431-447.

26. Buxton, P.A., & Mellanby, K. 1934. The measurement and control of humidity. Ibid. 25:171-175.

27. Carbonell, C.S. 1947. The thoracic muscles of the cockroach Periplaneta americana L. Smithson. Misc. Coll., 107 (2) : 23 pp.

28. " 1959. The external anatomy of the South American semi-aquatic grass hopper Marellia remipes Uvarov (Acridoidea : Paulinilidae) Ibid. 137 : 61-97.

29. Chadwick, L.E. 1959. Spinasternal musculature in certain insect orders. Ibid.137:117-156.

30. Cheema, P.S. 1951. A note on the morphology of the sugarcane root borer, Emmalocera depressella Swinhoe.Ind.Journ.Ent.13: 79-85.

31. Cook, E.F. 1944. The morphology and musculature of the labrum and clypeus of insects. Microent. 9 : 1-35.

31a.*

32. Crampton, G.C. 1926. A comparison of the neck and prothoracic sclerites throughout the orders of insects from the standpoint of phylogeny. Trans. Amer. ent. Soc. 52 : 199-248.

33. Das, G.M. 1937. Musculature of the mouth parts of insect larvae. Quart. Journ. Micr. Sci. 80 (317) : 39-80.

34. Day, M.F. 1954. The mechanism of food distribution to midgut or diverticula in the mosquito. Australian Journ. Biol. Sci. 1 : 515-524.

35. Day, M.F. & Waterhouse, D.F. 1953. Structure of the alimentary system. Insect Physiology (Edited by K.D.Roeder) : 270-310. John Wiley & Sons Inc. New York.

36. Demerec, M. 1950. Biology of Drosophilas 632 pp. John Wiley & Sons,Inc.New York.

37. Dhillon, S.S. The morphology and biology of the mustard sawfly Athalia proxima Klug. (Tenthredinidae, Hymenoptera). Alig.Musl.Univ.Publ. (Zool.Ser.) Ind.Ins.Typ. (in Press).

38. Duncan, C.D. 1939. A contribution to the biology of North American vespine wasps. Stanford Univ.Publ.Biol.Sci. 8 (1) : 272 pp.

39. DuPorte, E.M. 1946. Observations on the morphology of face in insects. Jour.Morph.79(3):371-417.

40. " 1956. The median facial sclerite in larval and adult Lepidoptera. Proc. R. ent. Soc.Lond.(A) 31 : 109-116.

41e&* DuPorte, E.M. 1963. The postentennal region of the insect embryo. Canad.J.Zool. 41 : 909-912.

42e&* " 1965. Notes on the morphology of the facial region in insects with special reference to that of larval Lepidoptera. Proc.R.ent.Soc.Lond. 40 (4-6) : 73-76.

41. DuPorte, E.M. 1957. The comparative morphology of
41a* the insect head. Ann.Rev.Ent.2:55-70.

42. " 1965. The lateral and ventral sclerites
42a*. of the insect thorax. Canad. J. Zool.
43 : 141-154.

43. DuPorte, E.M. & Bigelow, R.S. 1953. The clypeus and
the epistomal suture in Hymenoptera.
Ibid. 31 : 20-29.

44. Dyar, H.G. 1890. The number of moults of lepidopterous larvae. Psyche.5:420-422.

45. Eassa, Y.E.E. 1953. The development of imaginal buds in the head of Pieris Brassicae L. Trans. Roy. Ent. Soc. Lond.(104)(3) : 39-50.

46. " 1963. Metamorphosis of the cranial capsule and its appendages in the cabbage butterfly Pieris brassicae L. Ann.ent. Soc.Amer. 56 : 510-521.

47. " 1963. The musculature of the head appendages and the cephalic stomodaeum of Pieris brassicae L. (Lepidoptera : Pieridae). Ibid. 56 : 500 -510.

48. Eastham, L.E.S.& Eassa, Y.E.E. 1955. The feeding mechanism of the butterfly Pieris brassicae L. Phil.Trans. Roy. Soc. Lond. (B).239(659) : 1-43.

49. Eggers, F. 1919. Das thoracale bitympanale organ einer Gruppe des Lepidoptera,Heterocera. Zool.Jahrb.Abt.Anat. 41 : 273-376.

50. Ehrlich, P.R. 1958. The integumental anatomy of the monarch butterfly Danaus plexippus L. (Lepidoptera : Danaidae). Univ. Kansas Sci. Bull. 38 : 1315-1349.

51. Ehrlich, P.R. & Davidson, S.E. 1961. The internal anatomy of the monarch butterfly Danaus plexippus L.(Lepidoptera:Nymphalidae).Microent.26(3):85-133.

52. Evans, J.W. 1942. Further notes on the morphology of the insect head. Trans. Roy. Soc. S. Aust. Adelaide. 66 : 180-184.

53. Farooqui, M.M. 1963. The embryology of the mustard saw fly Athalia proxima Klug.(Tenthredinidae,Hymenoptera) Alig.Musl.Univ.Publ.(Zool. Ser.) Ind.Ins.Trn. 5 : 68 pp.

54. Ferris, G.F. 1940. The myth of thoracic sternites of Insects.Microent. 5(3) : 87-90.

55. " 1942. Some observations on the head of insects. Ibid. 7 (2) : 25-62.

56. " 1943. The basic materials of insect cranium. Ibid. 8 (1) : 8-24.

57. " 1943. Some fundamental concepts in insect morphology. Ibid.8 (1) : 2-7.

58. " 1944. On certain evolutionary tendencies in the heads of insects.Ibid.9(2):78-89.

59. " 1947. The contradictions of the insect head. Ibid. 12 (3) : 59-64.

60. Ferris, G.F. 1948. The principles of comparative morphology. Ibid. 13 (3) : 49-64.

61. " 1950. External morphology of the adult. Biology of Drosophila (Edited by Demerec,M.) 368-418. John Wiley & Sons.Inc.New York.

61a*

62. Fletcher, T.B. 1914. Some South Indian Insects and other animals of importance. Govt. Press, Madras: 565 pp.

63. " 1917. Rep. Proc. 2nd Ent. Meeting, Pusa: 340 pp.

64. Forbes, W.T.M. 1939. The muscles of the lepidopterous male genitalia. Ann.ent.Soc.Amer.32(1):1-10.

65. Gerould, J.H. 1938. The structure and action of the heart of Bombyx mori and other insects. Acta. Zool. 19 : 297-352.

66. Grell, K.G. 1938. Der Darmtraktus von Panorpa communis L. und seine Anhange bei larve und Imago (Ein Beitrage zur Anatomie und Histdlogie der Mecopteren). Zool. Jahrb. Anat. Band 64 :1-86.

67. " 1942. Der Genitalapparat von Panorpa communis L. (Ein weiterer Beitrag zür Anatomie und Histologie) Ibid.67(4):513-587.

68. Hannemann, H.J. 1954. Zur funktionallen Anatomie des männlichen Kopulationsapparates Von Argynnis paphia L. Zool.Anz.152 (9-10) : 266-274.

61a* Ferris,G.F. & Pennebaker, P. 1939. The morphology of Agulla adnixa H. (Neuroptera,Raphidiidae). Microent. 4 : 121-142.

69. Hannemann, H.J. 1954. Zur Muskel Funktion der weiblichen genital segmente von Argynnis paphia L. (Lep.) Ibid. 153 (7-8) : 149-154.

70. Henry, L.M. 1958. Musculature of the cervical region in insects. Microent.23(3) : 1-22.

71. Henson, H. 1931. The structure and postembryonic development of Vanessa urticae (Lep.). I- the larval alimentary canal. Quart. Journ. mic. Sci. 74 (294) : 321-359.

72. " 1932. The development of the alimentary canal in Pieris brassicae L. and the endodermal origin of the malpighian tubules of insects. Ibid. 75 : 283-309.

73. *Hering, M. 1926. Biologie der Schmetterlinge. Berlin : Springer.

74. Hinton, H.E. 1948. The dorsal cranial areas of caterpillars. Ann.&.Mag.Nat.hist.Soc. 14 (II): 843-852.

75. Imms, A.D. 1933. On the antennal musculature in insects and other Arthropods. Quart.Journ. mic. Sci. 81 : 272-320.

76. " 1957. A general textbook of Entomology (Revised by Richards & Davies). Methuen & Co. Ltd. London: 886 pp.

77. Kellogg, V.L. 1893. The sclerites of the head of Danies archippus F. Kansas Univ. Quart. 2 (2): 51-57.

78. Kellogg, V.L. 1895. The mouthparts of Lepidoptera. Amer. Nat. 29 : 546-556.

79. Kennel, J. von & Eggers, F. 1933. Die abdominalen tympanalorgane der Lepidoptera. Zool. Jahrb. [Abt. Anat. 57 : 1-104.

80. Khateeb, S.M.H. 1946. Studies in Galerucinae. The external morphology of Galerucilla birmanica J. Coleoptera, polyphaga, phytophaga. Proc. Ind.Acad.Sci. 23 (1) B :

81. " 1946. Studies in Galerucinae. The internal anatomy of Galerucilla birmanica J. Coleoptera, polyphaga, phytophaga, Chrysomelidae, Galerucinae.Ibid.24(2)B:

82. King, P.E. 1960. Technique for producing transparencies of female insects with the musculature stained in situ by a modification of the method used by Alam on male Stenobracon deesae Cameron (Hym.,Braconidae) The Ent.Monthly Mag. XCV.

83. *Kirbach, P. 1884. Über die mundwerkzeuge der Schmetterlinge. Arch.Naturgesch. 50 : 78 p.

84. Klots, A.B. 1956. Taxonomist's glossary of genitalia in insects (Edited by S.L.Tuxen): 97-111. Ejnar Munksgaard, Copenhagen.

85. Lal, M.M. 1917. Rep.Proc.2nd ent. meet.Pusa :67p. (Edited by T.B.Fletcher).

86. *Lameere, A. 1938. Precis de Zoologie. 5 Brussells. Universite de Bruxelle Institut Zoologique Forley-Rousseau.

87. Lefroy, H.M. 1909. Indian Insect Life. Thacker Spink & Co., London : 786 pp.

88. Libby, J.L. 1961. The nervous system of certain abdominal segments and the innervation of the male reproductive system and genitalia of Hyalophora cecropia (Lepidoptera:Saturnidae). Ann.ent.Soc.Amer.54(6) :887-896.

89. Madden, A.H. 1944. The external morphology of the adult tobacco hornworm Protoparce sexta (Lep.Sphingidae).Ibid. 37(4): 146-160.

90. Maki, T. 1938. Studies on the thoracic musculature of insects. Mem.Fac.Sci.Agri. Taihoku Imp.Univ.,24 : 1-343.

91. Malouf, N.S.B. 1933. Studies on the internal anatomy of the 'stink bug' Nezara viridula L.Bull. Soc.Ent.Egypte,Cairo. 16 : 161-203.

92. Martin, J.F. 1916. The thoracic and cervical sclerites of insects.Ann.ent.Soc.Amer.9(1) : 35-83.

93. Mathur, R.B. 1961. New type of extrinsic and intrinsic articulations of antenna of the Indian Sann hemp moth Utetheisa pulchella L. (Arctiidae:Lepidoptera).Ind.Journ.ent. 23 (4) : 282-284.

94. Mathur, R.B., Alam, S.M. & Khan, M.A. 1959. Mode of ingestion in Utetheisa pulchella L. (Abs.) Proc. 46th Session Ind.Sci.Congr. III :

95. Mathur, R.B. & Alam, S.M. 1960. Skeleto-muscular mechanism of the male genitalia of Utetheisa pulchella L. (Abs). Proc.Ind.Sci.Congr.47th Session, III.

100. Matsuda, R. 1956. The comparative morphology of the thorax of two species of insects. Microent. 21 (1) : 1-34.

101. " 1958. On the origin of external genitalia of insects. Ann.ent.Soc.Amer. 51 (1) : 84-94.

102. " 1960. Morphology of the pleurosternal region of the pterothorax in insects. Ibid. 53 (6) : 712-731.

103. " 1965. The Insect Head. American Congr. Ent.

104. Mayer, E.L. & Bebers, F.H. 1944. Head capsule measurements of Southern armyworm larvae (Prodenia eridania Cram.)Ann.ent.Soc.Amer. 37 (2) : 214-220.

105. Mehta, D.R. 1933. On the development of the male genitalia and the efferent genital ducts in Lepidoptera. Quart.Journ.mic.Sci. 76 (301): 35-61.

106. Mercer, E.H. & Day, M.F. 1952. The fine structure of the peritrophic membrane of certain insects. Biol. Bull. 103 : 384-394.

107. Michener, C.D. 1944. A comparative study of the appendages of the eighth and ninth abdominal segments of insects. Ann.ent.Soc.Amer. 37 : 336-351.

108. Miller, A. 1950. The internal anatomy and histology of the imago of Drosophila melanogaster. Biology of Drosophila.(Edited by

108a.** Demerec, M.):420-534. John Wiley & Sons Inc. New York.

109. Musgrave, A.J. 1937. The histology of the male and female reproductive organs of Ephestia kühniella Z. I- The young imagines. Proc. zool.Soc.Lond. 107 (3) : 337-364.

110. Nesbitt, H.J.H. 1941. A comparative morphological study of the nervous system of the Orthoptera and related orders. Ann.ent.Soc.Amer. 34 (1) : 51-81.

111. Norris, M.J. 1932. Contributions to the study of insect fertility. I- The structure and operations of reproductive organs in genera Ephestia and Plodia (Phycitidae). Proc. zool. Soc. Lond. 102 (3) : 595-611.

108a** Mortimer, T.J. 1965. The alimentary canals of some adult Lepidoptera and Trichoptera. Trans. R.ent.Soc.Lond.117(3) : 67-93.

112. Nüesch, H. 1953. The morphology of the thorax of Telea polyphemus (Lepidoptera). I. Skeleton and muscles. J. Morph. 93 (3): 589-609.

113. " 1957. Die Morphologie des Thorax von Telea polyphemus Cr.(Lepid.). II . Nervensystem.Zool.Jahrb.Anat.75(4) : 615-642.

114. Nutting, W.L. 1951. A comparative study of the heart and accessory structures of the Orthopteroid insects.J.Morph.89(3) : 501-593.

115. Okagaki, H., Sibatani, A., Ogata, M., & Okada, Y. 1955. Male genitalia of Lepidoptera. Morphology and nomenclature. II. Morphological significance of sacculus and Furca.Ann.ent.Soc.Amer.48(6):433-442.

116. Ogata, M., Okada, Y., Okagaki, H., & Sibatani, A. 1957. Male genitalia of Lepidoptera. Morphology and nomenclature. III. Appendages pertaining to the tenth somite. Ibid. 50 (3) :237-244.

117. Palm, N.B. 1949. The rectal papillae in insects. Acta.Univ.Lond.45 (8) : 1-30.

118. *Portier, P. 1949. La biologie des Lepidoptères Encyclopédie Entomologique. A. 23. Paris : Paul Lechevalier.

119. Puri, V.D. 1957. Studies on the anatomy of the sugarcane moth borers. Part. II. External anatomy of Chilo tumidicostalis-the stem borer of sugarcane. Proc. Ind.Acad.Sci. XLV(5)Sec.B : 196-215.

120. Pradhan, S., & Aren, N.S. 1941. Anatomy and musculature of Scirpophaga nivella. Ind. Journ. Ent. 3 (2) : 179-195.

121. Pyle, R.W. 1940. The anatomy and histology of the digestive system of a supposedly non-feeding adult moth, Callosamia promethea D.(Lep:Saturnidae). Ent. News, 51(7) : 181-185 and 211-215.

122. Qadri, M.A.H. 1933. The life-history and growth of the cockroach, Blatta orientalis L. Bull.ent.Res.29(3) : 263-276.

123. " 1940. On the development of the genitalia and their ducts of Orthopteroid insects. Trans. R. Ent. Soc. Lond. 90 (6) : 121-175.

124. " 1949. On the morphology and post-embryonic development of male genitalia and their ducts in Hemiptera. Journ. Zool.Soc.India 1 (2) : 129-143.

125. Qadri, M.A.H. & Asis, A. 1950. Biology, life-history and external and internal anatomy of

Pyrilla perpusilla W. Alig.Musl.Univ. Publ.(Zool.Ser.)Ind.Ins.Tyn.II: 35 pp.

126. Rakshpal, R. 1944. On the structure and development of the male reproductive organs in the Lepidoptera. Ind. Journ. Ent. 6 (1 & 2) : 87-93.

127. Ratiram. 1917. Rep.Proc.2nd Ent.meet.Pusa. 67 p.(Edited by T.B.Fletcher).

128. *Reaumur, M.de 1734. Mémoires pour servir a l' Histoire des insects. I. Paris: L Imprimerie, Loyale.

129. Richards, A.G. 1933. Comparative morphology of the noctuid tympanum. Entomologica Americana n.s., 13 : 1-44.

130. " 1963. The ventral diaphragm of insects J. Morph. 113 (1) : 17-48.

131. Ruckes, H. 1919. Notes on the male genital system in certain Lepidoptera. Ann. ent. Soc. Amer. 12 : 192-212.

132. Schmitt, J.B. 1938. The feeding mechanism of adult Lepidoptera.Smithson.Misc.Coll. 97 (4) : 28 pp.

133. " 1962. The comparative anatomy of the insect nervous system. Ann. Rev. ent. 7 : 137-156.

134. Schultz, H. 1914. Das pronotum und dis patagia der Lepidopteren. Deut. Ent. Ztschr. 17-42.

135. Shepard, H.H. 1930. The pleural and sternal sclerites of Lepidopterous thorax. Ann. ent. Soc. Amer. 23 : 237-260.

136. Short, J.R.T. 1951. Some aspects of the morphology of the head as seen in adult Lepidoptera. Proc.R.ent.Soc.Lond.(A) 26 : 77-88.

137. Sibatani, A., Ogata, M., Okada, Y., & Okagaki, H. 1954. Male genitalia of Lepidoptera. Morphology and nomenclature. I . Divisions of the valvae in Rhopalocera, Phalaenidae (=Noctuidae) and geometridae.Ann.ent.Soc.Amer.47(1) : 93-106.

138. Singh, M. 1941. New host plants of some Indian insects of economic importance. Ind. Journ. Ent. 3 (1) : 141 p.

139. Snodgrass, R.E. 1929. The thoracic mechanism of a grasshopper and its antecedents. Smithson. Misc. Coll. 82 (2) : 111 pp.

140. " 1931. Morphology of the insect abdomen I. General structure of the abdomen and its appendages. Ibid. 85(6) : 128 pp.

141. " 1933. Morphology of the insect abdomen. II. The genital ducts and the ovipositor. Ibid. 89(8) : 148 pp.

142. Snodgrass, R.E. 1935. Principles of Insect Morphology. 667 pp. McGraw Hill Book Co.N.y.

143. " 1936. Morphology of the insect abdomen. III. The male genitalia. Smithson.Misc.Coll.95 (14) : 96 pp.

144. " 1947. The insect cranium and the 'epicranial suture'. Ibid.107(7):52pp.

145. " 1952. A Text Book of Arthropod Anatomy. 363 pp

146. " 1956. Anatomy of the honey bee. 334 pp. Comstock Publ. Assoc.New York.

147. " 1957. A revised interpretation of the external reproductive organs of male insects. Ibid. 135 (6) : 60 pp.

148. " 1958. The insect tentorium and its antecedents. Proc. 10th Internl. Congr. Ent. 1 : 487 p.

149. " 1960. Facts and theories concerning insect head. Smithson Misc. Coll. 142(1) :61 pp.

150. Srivastava, A.S. Saksena, H.P. & Awasthi, G.P. 1963. Life history and control of Sann hemp hairy caterpillar, Utetheisa pulchella L.(Lepidoptera:Arctiidae). Labdev. J.S.T. 1.

151. Srivastava, B.K. & Mathur, L.M.L. 1964. Morphology and musculature of the head capsule of matûre larva of Prodenia litura F. (Lepidoptera,Noctuidae) Ind.Journ Ent. 26(1) :78-91.

152. Srivastava, B.P. 1960. Morphology of the reproductive organs of Leucinodes orbonalis G. (Lep:Pyraustidae).Part I. The female organs.Ibid.22 (1) : 35-46.

153. " 1960. Morphology of the reproductive organs of Leucinodes orbonalis G. (Lep:Pyraustidae). Part II. The male organs. Ibid. 22 (3) : 160-171.

154. Srivastava, K.P. 1957. On the morphology of the lemon butterfly Papilio demoleus (Lep.). Part I. Skeleto-muscular mechanism (Head and its appendages). Proc. nat. Acad. Sci. Allahabad (B)26(3):113-128.

155. " 1961. Studies on lemon butterfly Papilio demoleus L.(Lepidoptera).Part II. Skeleto-muscular mechanism (Cervix and Prothorax).Ind.Journ.Ent.23(3) : 202-213.

156. " 1962. Studies on lemon butterfly Papilio demoleus L.(Lepidoptera). Part III. Skeleto-muscular mechanism (Pterothorax and its legs).Ibid.24(2):114-134.

157. Tootia, T.P.S. & Pathak, M.D. 1956. Bionomics of the Sann hemp shoot borer Enarmonia pseudonectis M. (Eucosomidae:Lepidoptera) in Utter Pradesh.Ibid. 18 : 233-242.

158. " 1957. The anatomy of the larva of

Enarmonia pseudonectis M.(Eucosomidae: Lepidoptera). Ann.Zool.II(6) : 65-86.

159. Tonapi, G.T. 1959. On the structure and mechanism of the spiracular regulatory apparatus in the adult of Corydera cephalonica S. Curr.Sci.Bangalore,28(11) : 457-458.

160. Treat, A.E. 1959. The metathoracic musculature of Crymodes devastator B.(Noctuidae) with special reference to the tympanic organ. Smithson.Misc.Coll.137:365-377.

161. Viette, P. 1948. Morphologie des génitalia mâles des lepidoptères.Rev.franc.15 : 141-161.

162. Vasudeva, S. 1956. Studies on the morphology of the common lemon butterfly Papilio demoleus L.Journ.zool.Soc.Ind. 8 (2) : 211-233.

163. Waterhouse, D.F. 1953. The occurrence and significance of the peritrophic membrane with special reference to adult Lepidoptera and Diptera.Aust.Journ.Zool. 1 (3) : 299-318.

164. " 1953. Occurrence and endodermal origin of the peritrophic membrane in some insects.Nature 172 (676)p.

165. Weber, H. 1924. Das thorakaskelett der Lepidopteren.Zeitr.Anat.u.Entwickl. 73 277-331.

166. Weber, H. 1933. Lehrbuch der Entomologie. 726 pp. Jena.

167. Weil, E. 1935. Vergleichend-Morphologischen untersuchungen am Darmkanal einigen Apiden und Vespiden. Zeitschr.Morph. Okol. 30 : 438-478.

168. Wigglesworth,V.B. 1930. The formation of peritrophic membrane in insects with special reference to the larvae of mosquitoes. Quart.Journ.mic.Sci. 73 : 598-616.

169. " 1932. On the function of so called rectal glands of insects. Ibid. 75 : 131-150.

170. " 1953. The principles of Insect Physiology. 546 pp. Methuen, London.

171. Zaka-ur-Rab,M. 1961. Skeleto-muscular system of sucking pump of P.demoleus L.(Lepidoptera:Papilionidae).Curr.Sci.30:301-302.

172. " 1964. Observations on the facial sclerite of the larva of Papilio demoleus L.(Lepidoptera:Papilionidae). Proc.R.ent.Soc.Lond.(A)39(1-3):34-40.

173. Zander, E. 1903. Beitrage zur Morphologie der mannlichen Geschlechtsanhange der Lepidopteren.Z.Wiss.Zool.24:557-615.

*Refrences not seen in original and are available with Eastham & Eassa (1955).

7. A B B R E V I A T I O N S

T h e H e a d.

a	.....	Antennifer.
a'	.....	Apex of antennifer.
Ant	.....	Antenna.
Asoc	.....	Antennal socket.
AT	.....	Anterior tentorial arm.
at	.....	Anterior tentorial pit.
b	.....	Articular process of scape.
b'	.....	Concavity on the undersurface of the articular process of scape.
c	.....	Lateral articular knob of pedicel.
Ca	.....	Cardo.
cvx	.....	Cervix
d	.....	Lateral articular knob of the distal rim of scape.
db	.....	Dorsal bar
dfAT	.....	Dorsal flange of anterior tentorial arm.
dpl	.....	Dorsal plate of dorsal linkage of the proboscis.
E	.....	Compound eye.
e	.....	Apex of articular knob of pedicel.
end	.....	Endocuticular annuli of galea.
Ephy	.....	Epipharynx.
exc	.....	Exocuticular annuli of galea.
f	.....	Depression on the apex of articular knob of scape.

fc	.....	Salivary-cum-food canal.
Fl	.....	Flagellum.
fm	.....	Food meatus.
For	.....	Foramen magnum.
FrClp	.....	Frontoclypeus.
frGng	.....	Frontal ganglion.
Ga	.....	Galea.
Gab	.....	Galea base.
Ge	.....	Genae.
Hphy	.....	Hypopharynx.
HRA	.....	Anterior ridge of hypopharyngeal sclerotic plate.
HRV	.....	Ventral ridge of hypopharyngeal sclerotic plate.
HS	.....	Sclerotic triangular plate of hypopharynx.
iwGa	.....	Inner wall of galea.
Lb	.....	Labium.
Lbsoc	.....	Labial palp socket.
lfAT	.....	Lateral flange of anterior tentorial arm.
lfr	.....	Laterofacial ridge.
lfs	.....	Laterofacial suture.
Lm	.....	Labrum.
Md	.....	Mandible.
mfAT	.....	Mesal flange of anterior tentorial arm.
Mx	.....	Maxilla.
MxPlp	.....	Maxillary palp.

NSclb	.....	Oblique non-sclerotised band of galea.
O	.....	Ocellus.
or	.....	Ocular rim.
Pe	.....	Pedicel.
Pf	.....	Pilifer.
Phy	.....	Pharynx.
Poc	.....	Postocciput.
PoR	.....	Postoccipital ridge.
pos	.....	Postoccipital suture.
Prtl	.....	Parietal area.
PT	.....	Posterior tentorial arm.
pt	.....	Posterior tentorial pit.
q	.....	Stipital ridge.
ra	.....	Rim of antennal socket.
rLbPlp	.....	Basal rim of the labial palp.
rs	.....	Proximal rim of scape.
s	.....	Spines of galeal wall.
Sc	.....	Scape.
sld	.....	Common salivary duct.
slo	.....	Salivary orifice.
sloD	.....	Dorsal half of salivary orifice.
sloV	.....	Ventral half of salivary orifice.
slv	.....	Salivarium.
SP	.....	Sucking Pump.
sPr	.....	Roof of sucking pump.
Sscl	.....	Semi-sclerotised portion of labium.
st	.....	Stipes.

Stf	.....	Flat part of stipes.
Stt	.....	Tubular part of stipes.
StVlv	.....	Stipital valve.
Sttf	.....	Flexible wall of tubular stipes.
t	.....	Tooth of the ventral hook of galea.
tA	.....	Trifid apex of labium.
TB	.....	Tentorial bridge.
tm	.....	True mouth.
TrGes	.....	Transgenal suture.
TrPrtlR	.....	Trans-parietal ridge.
TrPrtls	.....	Transparietal suture.
Tsep	.....	Transverse septum of foramen magnum.
vh	.....	Ventral hook of the galea.
Vx	.....	Vertex.
x	.....	Ridge on the side of antennifer.
Y	.....	Mandibular line of flexion.
Z	.....	Dorso-lateral sclerotised plate of galea.

The Thorax.

a	.....	Base of the stem of third phragmanotum.
acP	.....	Articular concavity of prescutum.
acs	.....	Antecostal suture.
aE	.....	Anterior arm of meta-epimeron.
AEps	.....	Anepisternum.
af	.....	Axillary fissure.
ag	.....	Secondary plate of third phragmanotum.
ANP	.....	Anterior notal wing process.

so	.....	Stem of third phragmanotum.
sp	.....	Apophyseal pit.
ArkPg	.....	Basal lateral angle of patagium.
Ba	.....	Basalare.
BaAp	.....	Basalare apodeme.
Bac	.....	Concavity for articulation of basalare.
Bs	.....	Basisternum.
bTls	.....	Basal end of the protergal stem.
c	.....	Pleural articular knob for the coxa.
ConTla	.....	Concavity in the protergal arm for patagial articulation.
cv	.....	Cervical sclerite.
cvArkA	.....	Free end of the proximal portion of cervical sclerite.
cvArkl	.....	Lateral subtriangular projection of the cervical sclerite.
cvArkP	.....	Free end of the distal portion of the cervical sclerite.
cvx	.....	Cervix
d	.....	Sternal articular knob for the coxa.
dm	.....	Dorsal margin of subalare.
Epm	.....	Epimeron.
Epmd	.....	Postero-dorsal portion of epimeron.
Eps	.....	Episternum.
F	.....	Head of basalare apodeme.
FA	.....	Furcal arm.

Fs	.....	Furcasternum.
gr	.....	Sub-marginal groove of metathoracic subalare.
grR	.....	Sub-marginal ridge of metathoracic subalare.
i	.....	Inflected anterior margin of propleuron.
im	.....	Inflected mesal margin of metapleuron.
k	.....	Sternacostal suture.
ka	.....	Postero-mesal angle of katepisternum.
KEps	.....	Katepisternum.
l	.....	Secondary line of second thoracic phragma.
Lig	.....	Ligament between metathoracic subalare and second axillary sclerite.
lp	.....	Lateral process of neural plate of meta-endosternum.
lScut	.....	Lateral portion of meta-scutum.
m	.....	Third antecostal suture.
ma	.....	Mesal angle of subalare.
mb	.....	Membrane.
mi	.....	Marginal inflection of subalare.
mlgs	.....	Median longitudinal groove of furcasternum.
mls	.....	Mid-longitudinal suture of meso-scutum.
mScut	.....	Median portion of meta-scutum.
mvR	.....	Mid-longitudinal ridge of basisternum.
mvs	.....	Mid-longitudinal suture of basisternum.
N	.....	Neck of basalare apodeme.

n	.....	Less sclerotised plate of meta-scutum.
nf	.....	Neural passage of meta-endosternum.
np	.....	Neural plate of meta-endosternum.
Ncl	.....	Nodular sclerite.
o	.....	Point of bifurcation of the arms from the stem of third phragmanotum.
ob	.....	Anterior arm of third phragmanotum.
of	.....	Oblique fissure of scutum.
om	.....	Posterior arm of third phragmanotum.
P	.....	Secondary grooves of prothorax.
p	.....	Median protuberance of basisternal anterior margin.
PI	.....	Antero-dorsal auditory pocket.
P II	.....	Postero-dorsal auditory pocket.
P III	.....	Postero-ventral auditory pocket.
P IV	.....	Antero-ventral auditory pocket.
Pa	.....	Postalar bridge.
PAMP	.....	Pseudo-anterior metal wing process.
PaP1	.....	Anterior process of the postalar bridge.
PaP2	.....	Posterior process of the postalar bridge.
pb	.....	Posterior arm of the meta-epimeron.
Peps	.....	Pre-episternum.
PeR	.....	Pre-episternal ridge.
Pes	.....	Pre-episternal suture.
pg	.....	Patagium.
Ph	.....	Phragma.
PlA	.....	Pleural apophysis.

PlR ..... Pleural ridge.

Pls ..... Pleural suture.

PN ..... Phragmanotum (acrotergite).

PNArk ..... Phragmanotal articular knob.

PWP ..... Posterior notal wing process.

Pra ..... Prealar arm.

Prcx ..... Precoxal bridge.

Prsc ..... Prescutum.

PWP ..... Pleural wing process.

r ..... Secondary grooves of metathorax.

rM ..... Secondary grooves of mesothorax.

rp ..... Ridge of the first secondary groove of metathorax.

SA ..... Sternal apophysis.

Sa ..... Subalare.

SaSt ..... Stalk of metathoracic subalare.

sc ..... Antealbar socket of scutellum.

Scl ..... Scutellum.

Sct ..... Scutum.

spn ..... Spina.

SpnP ..... Spinal pit.

spR ..... Sterno-pleural ridge.

spu ..... Sterno-pleural suture.

Ss ..... Spinasternum.

Tl ..... Protergum.

TlA ..... Protergal arm.

TlS ..... Protergal stem.

TA ..... Tegular arm.

tf ..... Prescutal fissure.

Tg ..... Tegula.

Tga ..... Anterior end of tegula.

Tge ..... Posterior end of tegula.

Tgp ..... Tegular orifice.

Tm ..... Tympanal membrane.

Tp ..... Tegular plate.

tR ..... Prescutal ridge.

Trf ..... Transverse fissure of katepisternum.

TrR ..... Trans-episternal ridge.

Trs ..... Trans-episternal suture.

ts ..... Prescutal suture.

v ..... Posterior margin of basisternum.

vR ..... Scuto-scutellar ridge.

vs ..... Scuto-scutellar suture.

Wm ..... Axillary membrane of hind-wing.

Wmb ..... Axillary membrane of fore-wing.

Y ..... Flap like projection of furcal arm.

Y' ..... Flap like projection of the postero-dorsal portion of epimeron.

<u>The legs.</u>

Ar ..... Arolium.

arc ..... Arcus.

bb ..... Axis of movement of fore-coxa.

Bc ..... Basicosta.

bcs ..... Basicostal suture.

Bcx	.....	Basicoxite.
Btar	.....	Basitarsus.
Cx	.....	Coxa.
CxArc	.....	Concavity on the articular inflection of the fore-coxa.
CxArk	.....	Antero-lateral articular inflection of fore-coxa.
CxC	.....	Coxal socket.
CxDArk	.....	Distal articular knob of the coxa.
Cxg	.....	Coxa genuina.
CxLArc	.....	Lateral articular concavity of coxa.
CxMArc	.....	Mesal articular concavity of coxa.
Cxpr	.....	Proximal rim of coxa.
dapTb	.....	Dorsal apodeme of tibia.
dapTr	.....	Dorsal apodeme of trochanter.
DFm	.....	Distal portion of femur.
DFmLArk	.....	Lateral distal articular knob of femur.
e	.....	Emargination of the ventral half of the distal rim of femur.
em	.....	Trochanteral fossa in the coxa.
Epp	.....	Epiphysis of tibia.
Eppc	.....	Concavity in Tibia for epiphysis.
f	.....	Dorsal plate of tarsus.
Fm	.....	Femur.
FmArc	.....	Proximal articular knob of femur.
Fmr	.....	Proximal rim of femur.

Mer	.....	Meron.
miCxg	.....	Marginal inflection of coxa genuina
miMer	.....	Marginal inflection of meron.
mn	.....	Manubrium.
Pln	.....	Planta.
Ptar	.....	Pretarsus.
Pv	.....	Pulvillus.
s	.....	Spine of manubrium.
sg	.....	Secondary groove of the fore-coxa.
Tar	.....	Tarsus.
Tb	.....	Tibia.
TbLArk	.....	Lateral articular knob of tibia.
Tbr	.....	Proximal rim of tibia.
Tbs	.....	Tibial spur.
Tn	.....	Trochantin.
Tr	.....	Trochanter.
TrArkd	.....	Distal articular knob of trochanter.
TrArkP	.....	Proximal articular knob of trochanter.
Trr	.....	Proximal rim of trochanter.
u	.....	Median knob of the dorsal plate of tarsus.
un	.....	Claw of pretarsus.
unf	.....	Unguifer.
utr	.....	Unguitractor.
vapTb	.....	Ventral apodeme of tibia.
vapTr	.....	Ventral apodeme of trochanter.
vtar	.....	Ventral half of distal rim of last tarsomere.

x	.....	Posterior apodeme of femur.
z	.....	Sclerotic piece in the membrane connected to the proximal rim of coxa.

The wings.

A	.....	Anal vein.
A'	.....	Anal cell.
ab	.....	Posterior margin of mesothoracic first axillary sclerite.
Ap	.....	Ventral process of metathoracic second axillary sclerite.
Ax	.....	Axillary sclerite.
Axc	.....	Axillary cord.
b	.....	Postero-mesal angle of mesothoracic first axillary sclerite.
B	.....	Anterior process of metathoracic third axillary sclerite.
Bc	.....	Mesal margin of mesothoracic first axillary sclerite.
BD	.....	Anterior surface of metathoracic third axillary sclerite.
BO	.....	Mesal surface of metathoracic third axillary sclerite.
C	.....	Costa.
C'	.....	Costal cell.
cd	.....	Anterior margin of mesothoracic first axillary sclerite.

Cs	.....	Costal sclerite.
Cula	.....	Cubitusla.
Cula'	.....	Cubital la cell.
Culb	.....	Cubituslb.
Culb'	.....	Cubital lb cell.
D'	.....	Discal cell.
d	.....	Discal vein.
da	.....	Lateral margin of mesothoracic first axillary sclerite.
LLO	.....	Latero-posterior surface of metathoracic third axillary sclerite.
e	.....	Anterior angle of mesothoracic second axillary sclerite.
f	.....	Posterior angle of mesothoracic second axillary sclerite.
ff	.....	Fremular spines of female.
fm	.....	Fremular spine of male.
g	.....	Dorsal angle of mesothoracic second axillary sclerite.
h	.....	Ventral angle of mesothoracic second axillary sclerite.
HP	.....	Humeral plate.
J	.....	Jugum.
jf	.....	Jugal fold.
k	.....	Outer angle of mesothoracic third axillary sclerite.
L.	.....	Lateral projection of metathoracic

third axillary sclerite.

l ..... Anterior margin of mesothoracic third axillary sclerite.

m' ..... Anterior median plate.

m" ..... Posterior median plate.

m ..... Medial cross-vein.

M1 .... Media 1.

M1' ..... Medial 1 cell.

M2 ..... Media 2.

M2' ..... Medial 2 cell.

M3 ..... Media 3.

M3' ..... Medial 3cell.

mc ..... Marginal cell of hind-wing.

m - Cu ..... Medio-cubital cross-vein.

n ..... Curved process of mesothoracic third axillary sclerite.

O ..... Posterior process of metathoracic third axillary sclerite.

e ..... Emarginated anterior margin of mesothoracic third axillary sclerite.

p ..... Inner angle of mesothoracic third axillary sclerite.

R ..... Remigium.

r ..... Outer end of mesothoracic fourth axillary sclerite.

R1' ..... Radial 1 cell.

R2 ..... Radius 2.

R2'	.....	Radial 2 cell.
R3	.....	Radius32
R3'	.....	Radial 3 cell.
R4	.....	Radius 4
R4'	.....	Radial 4 cell.
R5	.....	Radius5
R5'	.....	Radial 5 cell.
rh	.....	Retinaculum of male.
r - m	.....	Radio-medial cross-vein.
Rs	.....	Radial sector.
Rs'	.....	Radial sector cell.
s	.....	Inner end of mesothoracic fourth axillary sclerite.
Scb	.....	Base of subcosta-cum-radius1.
Scp	.....	Basal articular process of subcosta-cum-radius1.
Sc + R1	.....	Subcosta-cum-radius1.
t	.....	Inner basal angle of metathoracic first axillary sclerite.
tv	.....	Inner wall of metathoracic first axillary sclerite.
u	.....	Outer basal angle of metathoracic first axillary sclerite.
ut	.....	Base of metathoracic first axillary sclerite.
uv	.....	Outer wall of metathoracic first axillary sclerite.

v	.....	Vertex of metathoracic first axillary sclerite.
vf	.....	Vannal fold.
w	.....	Anterior angle of metathoracic second axillary sclerite.
x	.....	Posterior angle of metathoracic second axillary sclerite.
y	.....	Mesal angle of metathoracic second axillary sclerite.
z	.....	Lateral angle of metathoracic second axillary sclerite.

The Abdomen

A	.....	Arm of IX sternum.
asp	.....	Anterior apodeme (of VIII segment).
Ac	.....	Antecosta.
acb	.....	Lobe of the second antecosta.
acs	.....	Antecostal suture.
amS7	.....	Anterior margin of VII sternum.
amS8	.....	Anterior margin of VIII sternum.
amS9	.....	Anterior margin of IX sternum.
amT7	.....	Anterior margin of VII tergum.
amT8	.....	Anterior margin of VIII tergum.
amT9	.....	Anterior margin of IX tergum.
as	.....	Dorsal angle of IX sternum.
ast	.....	Acrosternite.
AT	.....	Anal tube.
aT	.....	Antero-lateral angle of IX tergum.

atg	.....	Acrotergite.
B	.....	Base of the ninth sternum.
bcpx	.....	Bursa copulatrix.
bo	.....	Bursal orifice.
c	.....	Posterior end of the sclerotic bar of I sternum.
D	.....	Diaphragma.
d	.....	Antero-lateral angle of II sternum.
dl	.....	Dorsal sclerotic line of VIII tergum.
ema	.....	Emargination of the anterior margin of II sternum.
eml	.....	Emargination of the lateral margin of II sternum.
f	.....	Antero-lateral angle of VIII tergum.
g	.....	Antero-lateral angle of VIII sternum.
h	.....	Tympanal hood.
i	.....	Invagination of posterior margin of VII sternum of female.
i'	.....	Inflection of the lateral and posterior margins of VII sternum of female.
iwh	.....	Inner wall of tympanal hood.
l	.....	Line of bending of I tergum.
lmS7	.....	Lateral margin of VII sternum
lmT9	.....	Lateral margin of IX tergum.
lP	.....	Lateral projection of IX sternum.
ls	.....	Lateral sclerotic bar of I sternum.
lt	.....	Lateral tergite of I tergum.

m	.....	Apex of X tergum.
mb	.....	Membrane.
mP	.....	Median projection of IX sternum.
p	.....	Pocket of VIII sternum.
pap	.....	Posterior apodeme (of pseudo-ovipositor).
Pl	.....	Pleurite.
PlMmb	.....	Pleural membrane.
pmS7	.....	Posterior margin of VII sternum.
pmS9	.....	Posterior margin of IX sternum.
rd	.....	Dorsal half of the basal rim of X tergum.
rv	.....	Ventral half of the basal rim of X tergum.
S	.....	Sternum.
SAT	.....	Semi-sclerotised portion of the lateral wall of anal tube.
SclIT	.....	Sclerotic band of I tergum.
T	.....	Tergum.
s	.....	Secondary groove of II tergum.

The Male Genitalia.

a	.....	Semi-sclerotised portion of the paramere.
Aed	.....	Aedeagus.
AedAp	.....	Aedeagal apodeme.
am	.....	Anterior margin of the paramere.
aP	.....	Antero-dorsal angle of the paramere.
b	.....	Sclerotised portion of the paramere.
BP	.....	Basal plate.
da	.....	Dorsal area of the paramere.

Dej	.....	Ejaculatory duct.
dmm	.....	Dorso-mesal margin of the paramere.
dpr	.....	Dorsal process of the paramere.
dSclp	.....	Dorsal sclerotised plate of the endophallus.
Emph	.....	Endophallus.
f	.....	Line of flexion of the basal plate.
fs	.....	Folded suspensorium of the diaphragma.
la	.....	Lateral area of the paramere.
Pc	.....	Parameral cone.
Phtr	.....	Phallotreme.
Pmb	.....	Interparameral bridge.
Pmr	.....	Paramere.
Pmrl	.....	Parameral lobe.
r	.....	Inflection of the posterior margin of paramere.
s	.....	Spines on the inner wall of the endophallus.
sp	.....	Spines on the sclerotic portion of the lateral wall of aedeagus (left wall).
Tr	.....	Transtilla.
Tra	.....	Concave apical margin of transtilla.
v	.....	'V' shaped ridge of parameral lobe.
va	.....	Ventral area of the paramere.
vmm	.....	Ventro-mesal margin of the paramere.
vp	.....	Ventral plate of the endophallus.
vpr	.....	Ventral process of the paramere.

vSclp	.....	Ventral sclerotic plate of the endophallus.
x	.....	Middle portion of the anterior margin of the basal plate.
y	.....	Lateral portion of the anterior margin of the basal plate.

The Female Genitalia.

aap	.....	Anterior apodeme (of VIII segment).
amS	.....	Anterior margin of the sternum.
amT	.....	Anterior margin of the tergum.
An	.....	Anus.
b	.....	Bulb of the posterior apodeme.
bcpx	.....	Bursa copulatrix.
bd	.....	Bursal duct.
bo	.....	Bursal prifice.
bs	.....	Bursal sac.
ism	.....	Intersegmental membrane.
lp	.....	Lateral plate of the pseudo-ovipositor.
Opr	.....	Oviporus.
p	.....	Pocket of the seventh sternum.
pap	.....	Posterior apodeme (of pseudo-ovipositor).
Pl	.....	Pleurite.
pOvp	.....	Pseudo-ovipositor.
SG	.....	Attractant Gland.

The Internal Anatomy.

a	..... Dorsal cranial trachea.
Aa	..... Junction of atrium and spiracular trachea.
AcGl	..... Accessory Gland.
Aed	..... Aedeagus.
al	..... Anterior lip of the spiracle.
AN	..... Abdominal nerve.
An	..... Anus.
AnT	..... Antennal trachea.
AntL	..... Antennal lobe.
AntNv	..... Antennal nerve.
Ao	..... Aorta.
AoNv	..... Aortic nerve.
Aspr	..... Sclerotic anterior half of spiracular rim.
Atr	..... Atrium.
b	..... Dorso-lateral cranial trachea.
bb	..... Brush border.
bcpx	..... Bursa copulatrix.
bd	..... Bursal duct.
bej	..... Bulbous ejaculatorius.
BMB	..... Basement membrane.
bo	..... Bursal orifice.
Br	..... Brain.
1 Br	..... Protocerebrum.
2 Br	..... Deutocerebrum.
3 Br	..... Tritocerebrum.

brEpth	.....	Bifurcation of rectal epithelium.
bs	.....	Bursal sac.
bsam	.....	Bulla seminalis.
BW	.....	Body wall.
c	.....	Ventro-lateral cranial trachea.
Ca	.....	Corpora allata.
Cc	.....	Corpora cardiaca.
Ch	.....	Chorion.
Cm	.....	Chamber of the heart.
cmcl	.....	Circular muscle layer.
CNv	.....	Cervical nerve.
CoeCon	.....	Circum-oesophageal connective.
Cr	.....	Crop.
Cst	.....	Sperm cyst.
Ct	.....	Connective tissue.
D	.....	Dorsal trachea.
d	.....	Ventral cranial trachea.
dAcGl	.....	Duct of accessory gland.
dDph	.....	Dorsal diaphragm.
dDphMcl	.....	Alary muscle of the dorsal diaphragm.
Dej	.....	Ejaculatory duct.
dh	.....	Dorsal hinge line of the spiracular lips.
dN	.....	Diaphral nerve.
dp	.....	Dorsal process of the posterior lip of the spiracles.
E	.....	Compound eye.

e	.....	Anterior trachea.
En	.....	Enzymes.
epi	.....	Inner epithelium of the testis.
epo.	.....	Outer epithelium of the testis.
Epth	.....	Epithelium.
ex	.....	Extension of follicular epithelium between the oocyte and the nurse cells.
fa	.....	Filtering apparatus of the spiracle.
fAo	.....	Aortic funnel.
fc	.....	Follicular cells of the germarium.
fEpth	.....	Follicular epithelium.
fNv	.....	Frontal nerve.
fo	.....	Follicle of the vitellarium.
Fol	.....	Testicular follicle.
frCon	.....	Frontal ganglion connective.
frGng	.....	Frontal ganglion.
gn	.....	Chromatin granules.
Gng	.....	Ganglion.
gr	.....	Groove of the protocerebral lobes.
Grm	.....	Germarium.
h	.....	Antero-dorsal thoracic trachea.
hGng	.....	Hypocerebral ganglion.
HphyNv	.....	Hypopharyngeal nerve.
Ht	.....	Heart.
ILrp	.....	Inner layer of rectal papilla.
In	.....	Intima.

InPr	.....	Intimal process.
Int	.....	Intestine.
j	.....	Postero-dorsal thoracic trachea.
k	.....	Aortic diverticulum.
l	.....	Leg trachea.
LbNv	.....	Labial nerve.
lD	.....	Lumen of salivary duct.
le	.....	Lever of the spiracular valve.
lG	.....	Lumen of the salivary gland.
lInt	.....	Lumen of the intestine.
lM	.....	Lumen of the mesenteron.
lmcl	.....	Longitudinal muscle layer.
lmNv	.....	Labral nerve.
LN	.....	Lateral nerve.
lN	.....	Leg Nerve.
lsD	.....	Lateral salivary duct.
LT	.....	Lateral tracheal trunk.
Mal	.....	Malpighian tubules.
mclr	.....	Radiating muscles of the bursa copulatrix.
MdNv	.....	Mandibular nerve.
Ment	.....	Mesenteron.
MN	.....	Median nerve.
MxNv	.....	Maxillary nerve.
N	.....	Nucleus of the oocyte.
NA	.....	Anterior nerve of the sixth abdominal ganglion of the male.

Nf	.....	Nerves of the sixth abdominal ganglion of the female.
ni	.....	Nidus.
NM	.....	Middle nerve of the sixth abdominal ganglion of the male.
NP	.....	Posterior nerve of the sixth abdominal ganglion of the male.
nr	.....	Nucleus of the regenerative cell.
NrC	.....	Nurse cell.
nu	.....	Nucleus.
nuN	.....	Nucleus of the nurse cell.
O	.....	Ocellus.
o	.....	Upper branch of abdominal dorsal trachea.
oc	.....	Ocellar trachea.
Odc	.....	Common oviduct.
Odl	.....	Lateral oviduct.
Oe	.....	Oesophagus.
OeNv	.....	Oesophageal nerve.
oEpth	.....	Old epithelium.
oLrp	.....	Outer layer of rectal papilla.
ONv	.....	Ocellar nerve.
Ooc	.....	Oocyte.
Oog	.....	Oogonia.
OpL	.....	Optic lobe.
OP	.....	Lamina dentata.
Ost	.....	Ostium.
Ovl	.....	Ovariole.

p	.....	Lower branch of abdominal dorsal trachea.
pcNv	.....	Paracardiac nerve.
pcs	.....	Pericardial sinus.
pepi	.....	Pigment of the inner epithelium of testis.
Phy	.....	Pharynx.
PL	.....	Papillar lumen.
pl	.....	Posterior lip of the spiracle.
pns	.....	Perineural sinus.
pOvp	.....	Pseudo-ovipositor.
Proc	.....	Proctodaeum.
Prvent	.....	Proventriculus.
ps	.....	Peritoneal layer.
pspr	.....	Membranous posterior half ofthe spiracular rim.
Pvlv	.....	Proctodaeal valve.
q	.....	Upper branch of abdominal ventral trachea.
r	.....	Lower branch of the abdominal ventral trachea.
raw	.....	Reticulate inner wall of the atrium.
Rect	.....	Rectum.
ResAcGl	.....	Reservoir of the accessory gland of male.
ResGl	.....	Reservoir of the accesory gland of female.
ResS	.....	Reservoir of the salivary gland.
rg	.....	Regenerative cell.
RN	.....	Rectal nerve.

rNv	.....	Recurrent nerve.
rp	.....	Rectal papilla.
rr	.....	Ventral tracheal commissure.
RT	.....	Root trachea.
S	.....	Testicular trachea.
sb	.....	Striated border.
sd	.....	Seminal duct.
Secr.	.....	Secretion.
Sep	.....	Testicular septa.
sEpth	.....	Syncytial epithelium.
SlD	.....	Common Salivary duct.
SlGl	.....	Salivery gland.
slo	.....	Salivery orifice.
slv	.....	Salivarium.
sn	.....	Spines.
SoeGng	.....	Suboesophageal ganglion.
sp	.....	Sucking pump.
spap	.....	Spiracular aperture.
Spd.	.....	Spermatid.
Spg	.....	Spermatogonium.
Spr	.....	Spiracular rim.
spt	.....	Spiracular trachea.
SptD	.....	Spermathecal duct.
SptGl	.....	Spermathecal gland.
Sptr	.....	Spermathecal reservoir.
Sps	.....	Spermatodium.

Stom	.....	Stomodaeum.
Svlv	.....	Stomodaeal valve.
tc1	.....	Upper tracheal commissure.
tc2	.....	Lower tracheal commissure.
Tes	.....	Testis.
tg	.....	Genital trachea.
tgv2	.....	Parameral trachea.
tr	.....	Trachea.
UN	.....	Unpaird nerve of the sixth abdominal ganglion of the female.
V	.....	Ventral trachea.
vac	.....	Vacuole.
vag	.....	Vagina.
vd	.....	Vas deferens.
vDph	.....	Ventral diaphragm.
vDphMcl	.....	Alary muscle of the ventral ddaphragm.
vh	.....	Ventral hinge line of the spiracular lips.
vlv	.....	Spiracular valve.
VNC	.....	Ventral nerve cord.
vp	.....	Ventral process of the spiracular rim.
vs	.....	Visceral sinus.
vsm	.....	Seminal vesicle.
W	.....	Wing trachea.

WN ..... Wing nerve.

x,x ..... Lumina of the spermathecal duct.

ylk ..... Yolk.

The Larval Anatomy.

a ..... Posterior mandibular articulation.

a' ..... Articular knob of cardo.

aa' ..... Dorsopleural line of the thorax.

a'b ..... Dorsopleural line of the abdomen.

Abap ..... Posterior apodeme of mandible.

ACLp ..... Anteclypeus.

Adap ..... Anterior apodeme of mandible.

AFrons ..... Antefrons.

Ant ..... Antenna.

AP ..... Apical plate of the terminal lobe.

Asoc ..... Antennal socket.

AT ..... Anterior tentorial arm.

at ..... Anterior tentorial pit.

b ..... Concavity in the proximal margin of the trochanter.

b' ..... Articular knob of the coxa.

BP ..... Basal plate of the terminal lobe.

c ..... Anterior mandibular articulation.

Cb ..... Cibarium.

Cd ..... Cardo.

CGR ..... Clypeogenal ridge.

CGS ..... Clypeogenal suture.

Clp ..... Clypeus.

Cs ..... Coxal suture.

ct ..... Crochet.

Cx ..... Coxa.

Cxb ..... Second segment of the proleg.

d ..... Dentations of the mandible.

Ecl ..... Ecdyseal cleavage line.

e ..... First dorsal abdominal pleurite.

f ..... Second abdominal pleurite.

Fm ..... Femur.

fMb ..... Flexible integument of the proleg.

For ..... Foramen magnum.

Fr. ..... Frons.

FrClp ..... Frontoclypeus.

FrGng ..... Frontal ganglion.

g ..... Second ventral abdominal pleurite.

Ga ..... Galea.

Ge ..... Gena.

h ..... First ventral abdominal pleurite.

hs ..... Hypostomal suture.

Hphy ..... Hypopharynx.

Hst ..... Hypostoma.

i ..... Concavity in the proximal rim of tibia.

i' ..... Outer angle of femur.

j	.....	Concavity in the proximal rim of tarsus.
j'	.....	Outer angle of tibia.
l	.....	Lateral abdominal tergite of the ninth segment.
L	.....	Leg.
LbPlp	.....	Labial palp.
Lm	.....	Labrum.
Lo	.....	Terminal lobe of maxilla.
m	.....	Dorsal abdominal tergite of the anterior row.
m'	.....	Articular knob of tarsus.
m''	.....	Concavity in the base of the claw.
Md	.....	Mandible.
mr	.....	Mandibular ridge.
MCR	.....	Midcranial ridge.
MCS	.....	Midcranial suture.
Mx	.....	Maxilla.
MxPlp	.....	Maxillary palp.
n	.....	Dorsal abdominal tergite of the posterior row.
O	.....	Ocellus.
o	.....	Ventral abdominal tergite of the anterior row.
p	.....	Ventral abdominal tergite of the posterior row.
PClp	.....	Postclypeus.

Pe	..... Apical segment of the antenna.
PFrons	..... Postfrons.
Phy	..... Pharynx.
PL	..... Proleg.
Pln	..... Planta.
Pmt	..... Postmentum.
Poc	..... Postoccipiut.
Pos	..... Postoccipital suture.
Pr	..... Silk press.
Prb	..... Pupal probascis.
Prmta	..... 'U' shaped portion of prementum.
Prmtb	..... Collar shaped portion of prementum
Prtl	..... Parietal.
pt	..... Posterior tentorial pit.
PT	..... Posterior tentorial arm.
Ptar	..... Pretarsus.
q	..... Stipital ridge.
r	..... Articular knob of stipital ridge.
Rph	..... Raphe.
S	..... Abdominal segment.
Sc	..... Basal segment of the antenna.
Sn	Spines of the proleg.
Sp	..... Spiracle.
Sr	..... Spinneret.
St	..... Stipes.
~~Stm~~ Sta	..... Setae

t	.....	Median abdominal tergite of the tenth segment.
T	.....	Thoracic segment.
TT	.....	Dorsal tergites of the thorax.
Tar	.....	Tarsus.
Tb	.....	Tibia.
TCR	.....	Transclypeal ridge.
TCS	.....	Transclypeal suture.
Tr	.....	Trochanter.
VT	.....	Ventral tergites of the thorax.
W	.....	Pupal wing.

8. EXPLANATION OF FIGURES.

PLATE I

Head.

Fig. 1. Anterior view of head capsule.

Fig. 2. Posterior view of head capsule.

Fig. 3. Inner view of head capsule after removal of its anterior wall.

Fig. 4. Antenna with antennal socket and intrinsic muscles.

Fig. 5. A portion of antennal rim with antennifer.

Fig. 6. A portion of proximal rim of scape with its articular process.

Fig. 7. Junction of scape and pedicel with their dorsal walls removed.

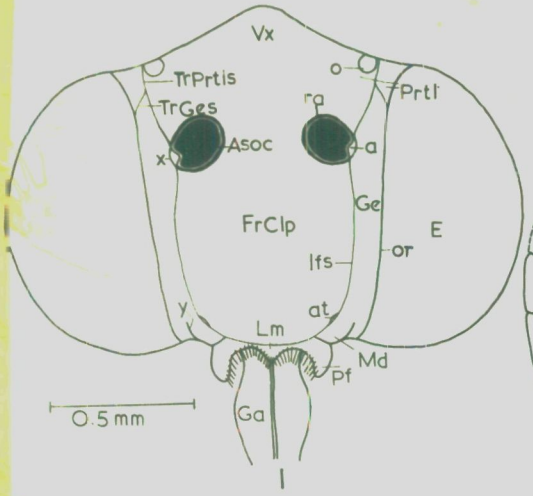
Fig. 8. Proximal rim of scape with extrinsic muscles.

Fig. 9. Inner view of the ventral walls of scape and pedicel showing intrinsic muscles of the antenna.

P L A T E S.

(I - XXVII)

PLATE I



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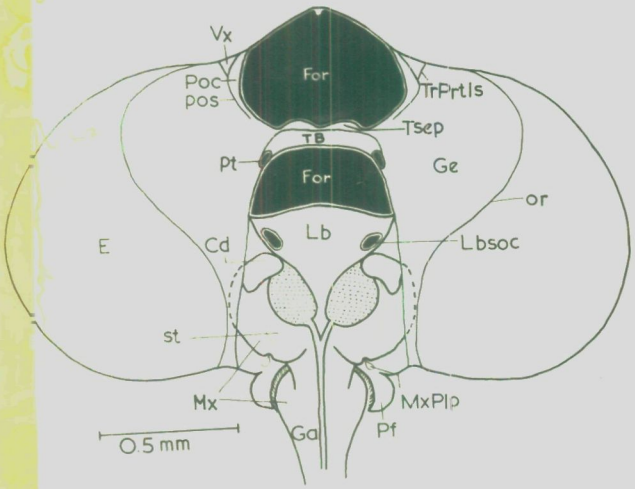

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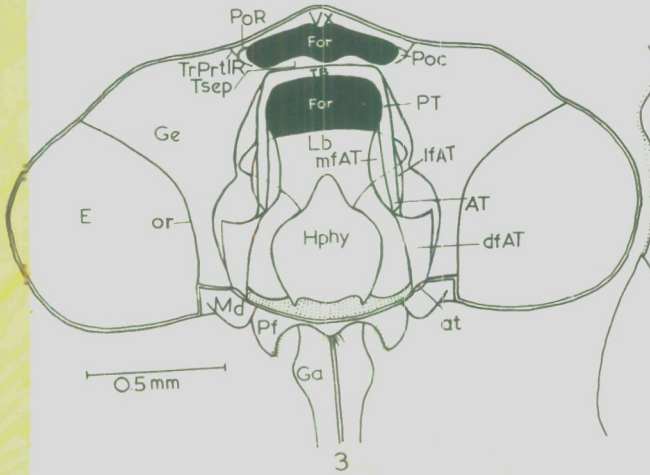

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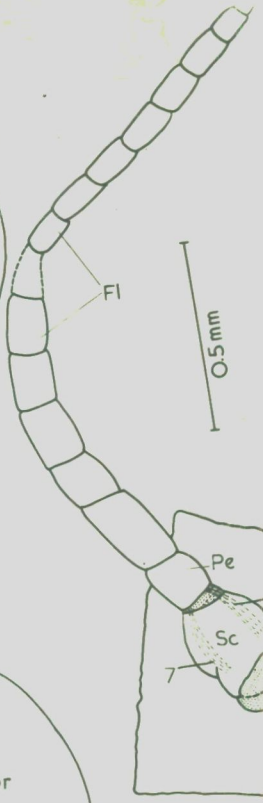

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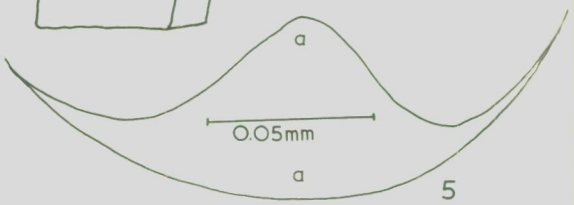

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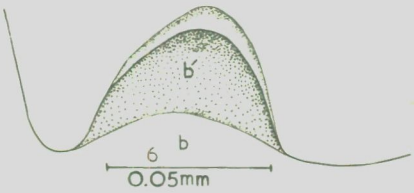

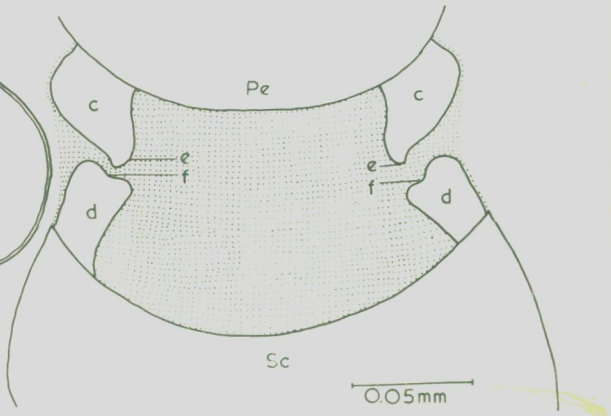

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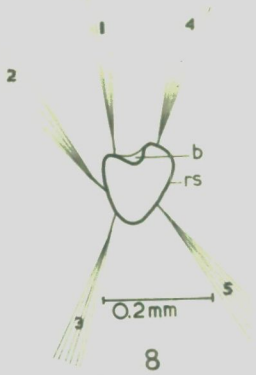

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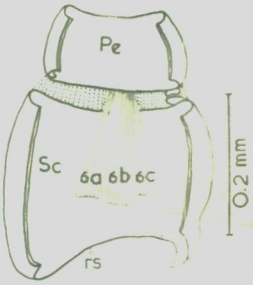


9

PLATE II

Head (contd.).

Fig. 10. Dorsal view of a portion of maxilla.

Fig, 11. Ventral view of a portion of maxilla.

Fig. 12. T.S. of stipes through stipital valve,

Fig. 13. T.S. of basal region of proboscis.

Fig. 14. L.S. of galea base.

Fig. 15. L.S. of a portion of galea in coiled state.

Fig. 16. L.S. of a portion of galea in extended state.

Fig. 17. T.S. of proboscis in its middle.

Fig. 18. T.S. of proboscis near its apical region.

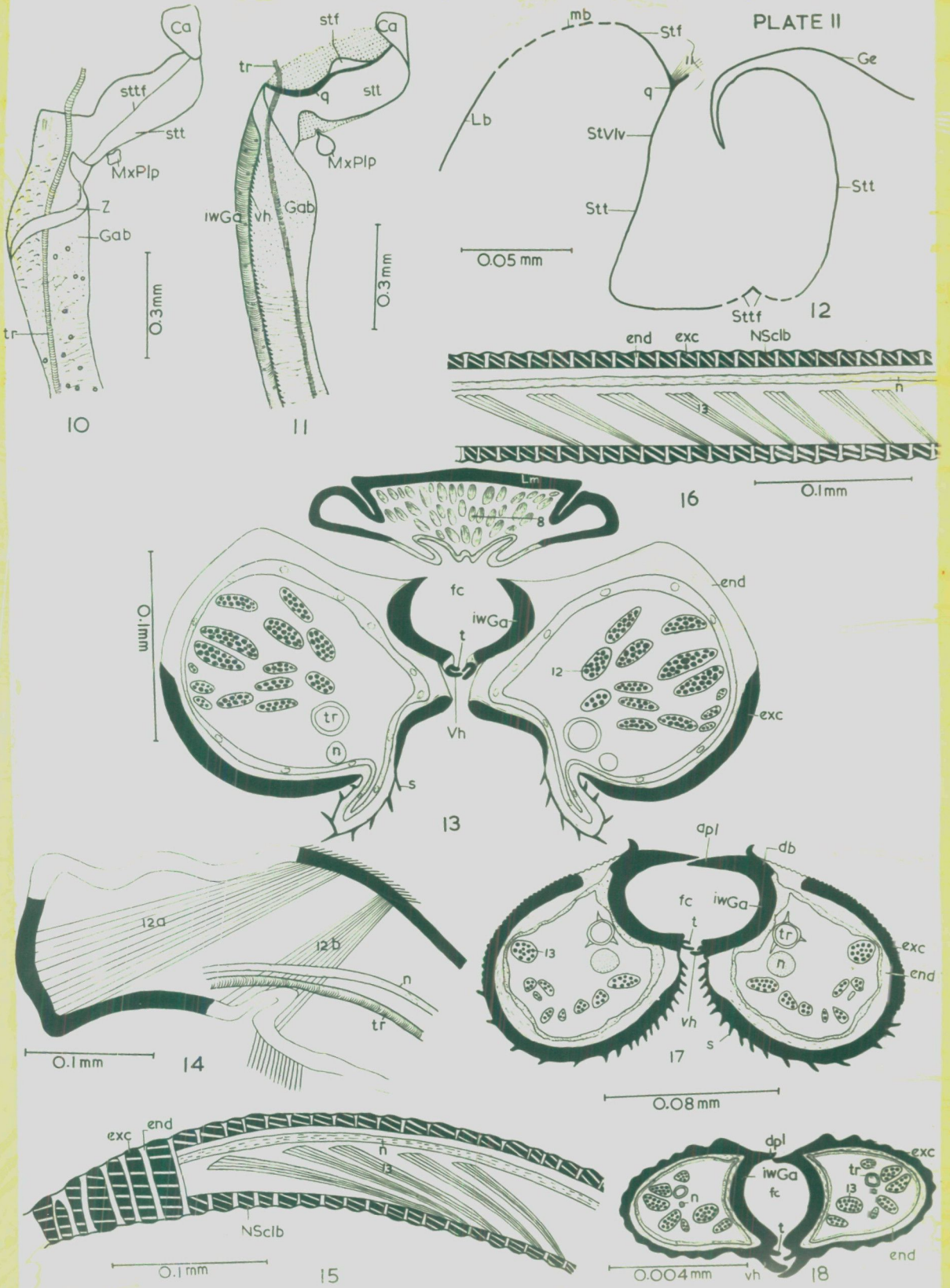


PLATE II
Ca
sttf
stt
MxPlp
Z
Gab
tr
0.3mm
10
stf
Ca
tr
q
stt
MxPlp
iwGa
vh
Gab
0.3mm
11
mb
Stf
q
Lb
StVlv
Stt
0.05 mm
Ge
Stt
Sttf
12
end
exc
NSclb
n
13
0.1mm
16
Lm
8
0.1mm
fc
iwGa
t
end
12
exc
tr
n
Vh
s
13
dpl
db
fc
iwGa
t
tr
n
13
exc
end
vh
s
17
0.08 mm
12a
12b
n
tr
0.1 mm
14
exc
end
n
13
NSclb
0.1 mm
15
dpl
exc
iwGa
tr
fc
n
13
t
end
0.004 mm
vh
18

PLATE III

Head (contd.).

Fig. 19. Inner view of the lateral half of head showing muscles.

Fig. 20. Ventral view of labium.

Fig. 21. Dorsal view of labium.

Fig. 22. Dorsal view of hypopharynx.

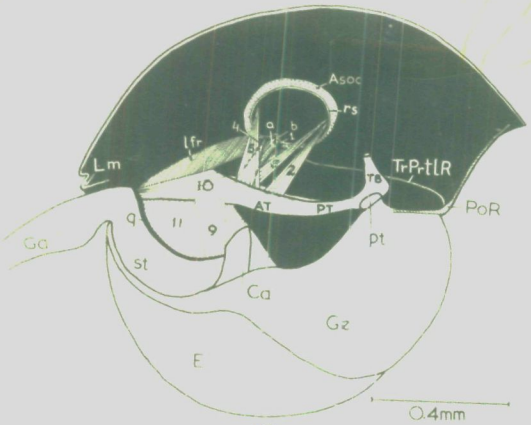
Fig. 23. Ventral view of sucking pump.

Fig. 24. Sucking pump with its muscles seen through dorsal incision.

Fig. 25. Sagittal section of head capsule.

Fig. 26. T.S. of head capsule passing through sucking pump.

PLATE III



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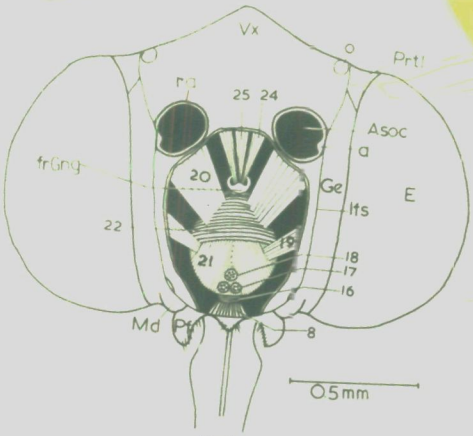

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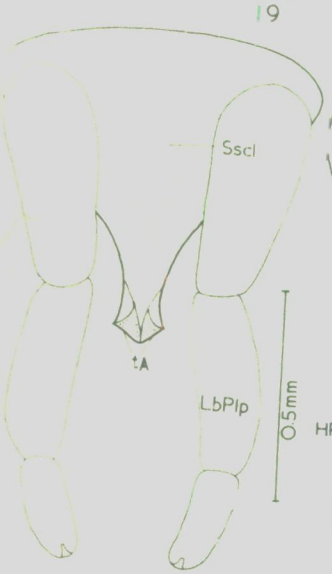

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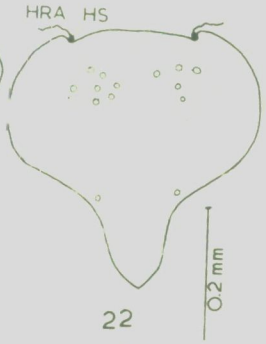

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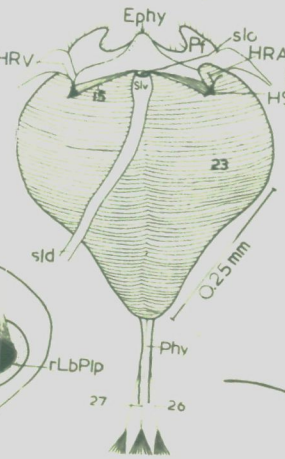

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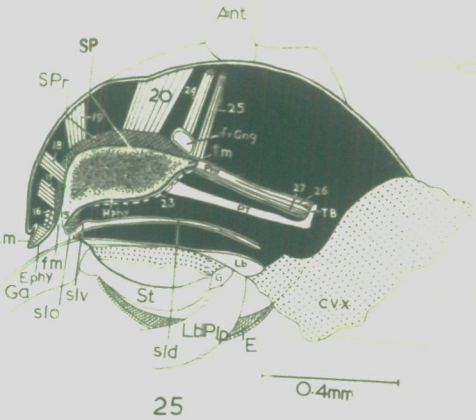

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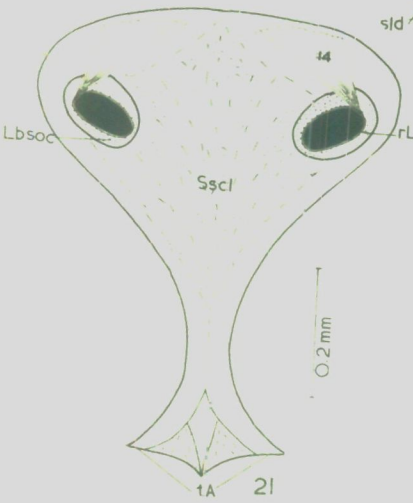

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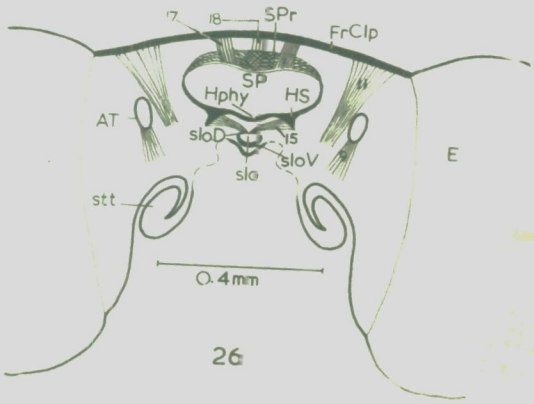

26

PLATE XV

Thorax

Fig. 27. Dorsal view of the thorax.

Fig. 28. Antero-dorsal view of prototergum and a portion of mesotergum.

Fig. 29. Anterior view of prothorax.

Fig. 30. Lateral view of propectus.

Fig. 31. Inner view of lateral half of propectus and endosternum.

Fig. 32. Ventral view of prothorax.

Fig. 33. Lateral view of a portion of furcasternum and spinasternum.

Fig. 34. Fore-leg.

Fig. 35. Coxo-trochanteral articulation.

PLATE IV

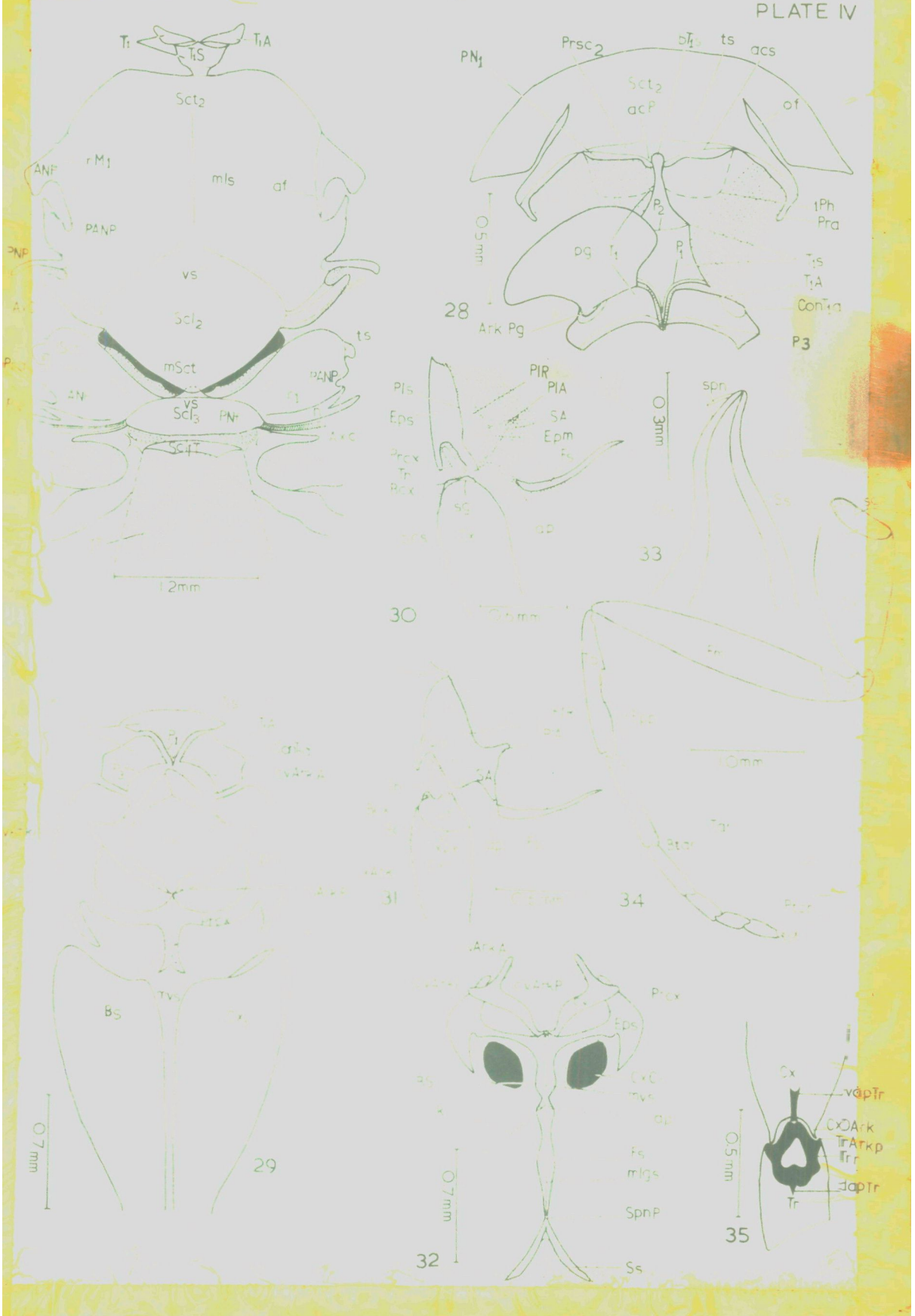
T1
T1S
T1A
Sct2
rM1
ANF
mls
af
PANP
vs
Scl2
ts
mSct
AN
Scl3
PNF
Scl1
1.2mm
PN1
Prsc2
bT1
ts
acs
Sct2
acP
af
0.5mm
P2
P1
pg
T1
1Ph
Pra
T1s
T1A
ConTa
28
Ark Pg
P3
PIR
PIA
PIs
Eps
SA
Epm
Fs
Prox
Tr
Rdx
0.3mm
spn
33
30
1.0mm
31
34
BS
0.7mm
29
ArkA
vArkP
Prox
Eps
Fs
mlgs
SpnP
Ss
0.7mm
32
Cx
vapTr
CxDArk
TrArkp
Trr
dapTr
Tr
0.5mm
35

PLATE V

Thorax (contd.).

Fig. 36. Trochantero-femoral articulation with articular surfaces separated.

Fig. 37. Femoro-tibial articulation with articular surfaces separated.

Fig. 38. Dorsal view of pretarsus.

Fig. 39. Ventral view of pretarsus.

Fig. 40. Inner view of lateral half of prothorax with extrinsic muscles of the head and the muscles of prothorax.

Fig. 41. Inner view of lateral half of prothorax with its muscles.

Fig. 42. Lateral view of prothorax with muscles.

Fig. 43. Proximal rim of fore-coxa with muscles.

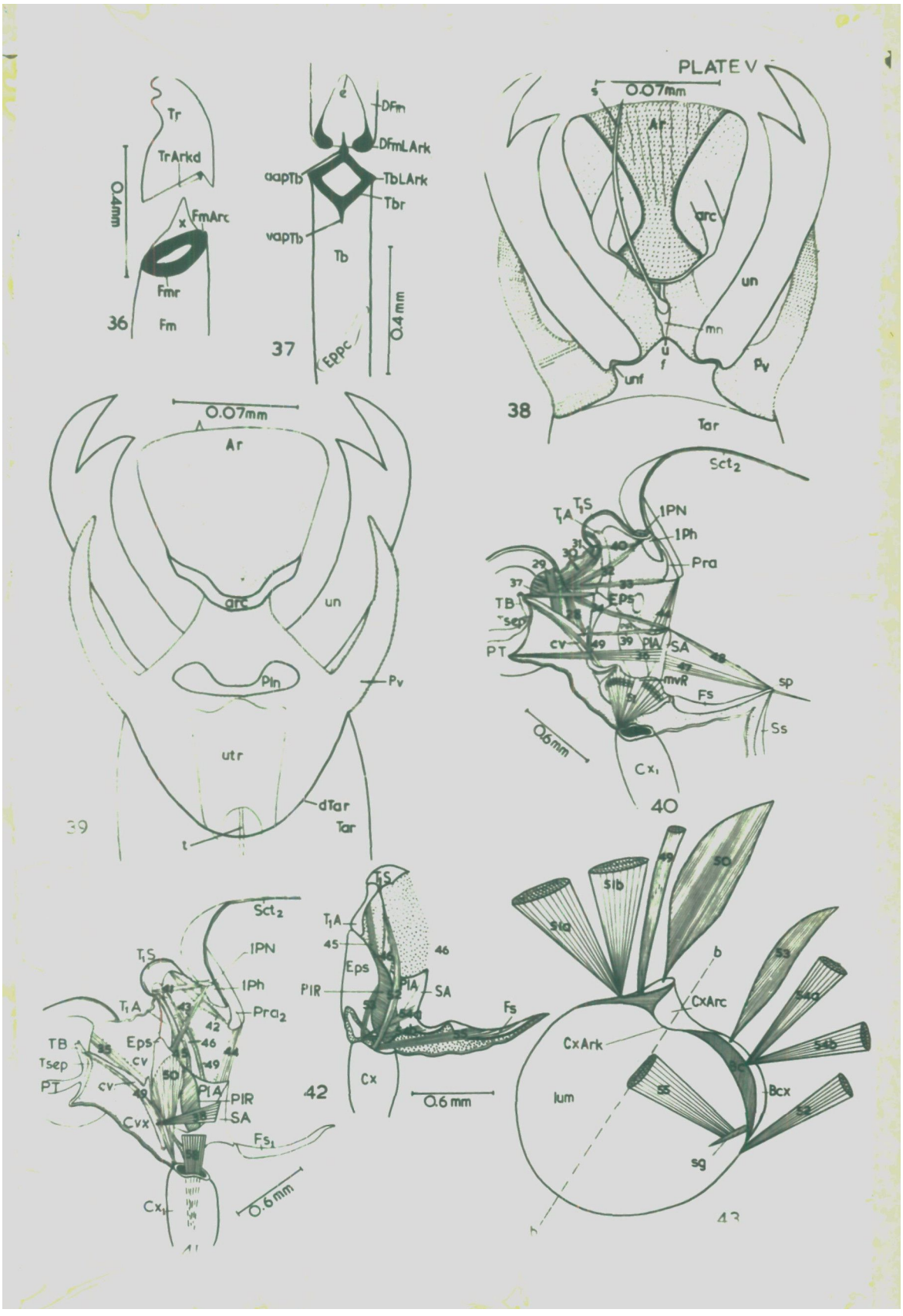
PLATE V
Tr
TrArkd
0.4mm
x
FmArc
Fmr
Fm
36
e
DFm
DfmLArk
aaptTb
TbLArk
Tbr
vaptTb
Tb
0.4 mm
Eppc
37
s
0.07mm
Ar
arc
un
mn
u
f
Pv
unf
38
Tar
0.07mm
Ar
arc
un
Pln
Pv
utr
dTar
Tar
t
39
Sct2
T1A
T1S
1PN
1Ph
Pra
TB
Eps
Tsep
PT
cv
PIA
SA
mvR
Fs
sp
Ss
0.6mm
Cx1
40
Sct2
T1S
1PN
1Ph
T1A
Pra2
TB
Eps
Tsep
PT
cv
PIA
PIR
SA
Cvx
Fs1
Cx1
0.6mm
41
T1S
T1A
45
46
Eps
PIR
PIA
SA
Fs
Cx
42
0.6 mm
Sta
Stb
49
50
b
CxArc
CxArk
lum
Bcx
sg
53
Sta
Stb
55
43

PLATE VI

Thorax (contd.).

Fig. 44. Fore-leg with intrinsic muscles.

Fig. 45. Fore-leg with intrinsic muscles.

Fig. 46. Lateral view of mesothorax.

Fig. 47. Inner view of lateral half of mesothorax.

Fig. 48. Dorsal view of second phragmasternum with the second phragma.

Fig. 49. Sagittal section of pro, meso and a portion of meta-terga.

Fig. 50. Ventral view of mesothorax.

PLATE VI


Fm 1.0mm
Tb
Epp
Btar
t
Tar
Ptar
1Ph
Pra
Ba
56
58
Cx
59
57
60
61
Tr
44
Sct
Scl
Con
rM1
rM2
PWP
ANP
af
vs
sc
PaP1
Axc
PN2
acs
Pa
2 ph
1
45
TP
ts
of
TA
PANP
PNP
Sa
PaP2
rM7
Epmd
AEps
rM4
Wmb
Trs
Epm
rM6
Trf
pls
rM5
kEps
Pes
Peps
rM3
Mer
c
bcs
Cxg
1.0mm
0.5mm
Tgo
Tge
46
46a
tR
Con
Sct
rM1
1Ph
TA
ANP
Pm
Ba
PANP
Scl
BaAp
AEps
rM2
PNP
PaP1
vR
TrR
Sa
m
Pa
PN2
acs2
Trf
Fs1
Wmb
Prsc3
1
PaP2
PIR
rM5
Epm
Epmd
Ss
rM6
Eps
bcs
FA
mvR
SA
Fs
2Ph
0.2mm
Cxg
d
Mer
47
0.5mm
PNArk
Pa
acs
PN2
1
2Ph
48
Sct2
vR
Scl2
mb
PN2
Prsc3
Sct3
acs2
2Ph
tR
acs1
Ti
mb
PN1
1Ph
1.0 mm
49
AEps
1.0mm
Trs
Ss
Trf
kEps
Peps
Pes
c
rM3
Epm
sps
bcs
Bs
mvs
Cxg
ka
Mer
d
50

PLATE VII

Thorax (contd.).

Fig. 51. Dorsal view of meso-endosternum with coxa.

Fig. 52. Middle-leg.

Fig. 53. Proximal rim of middle-coxa.

Fig. 54. Distal rim of middle-coxa.

Fig. 55. Inner view of the lateral half of mesothorax with muscles of the fore-wing.

Fig. 56. Inner view of the lateral half of mesothorax with muscles of the middle-leg.

Fig. 57. Inner view of the lateral half of mesothorax with muscles of the fore-wing and the middle-leg.

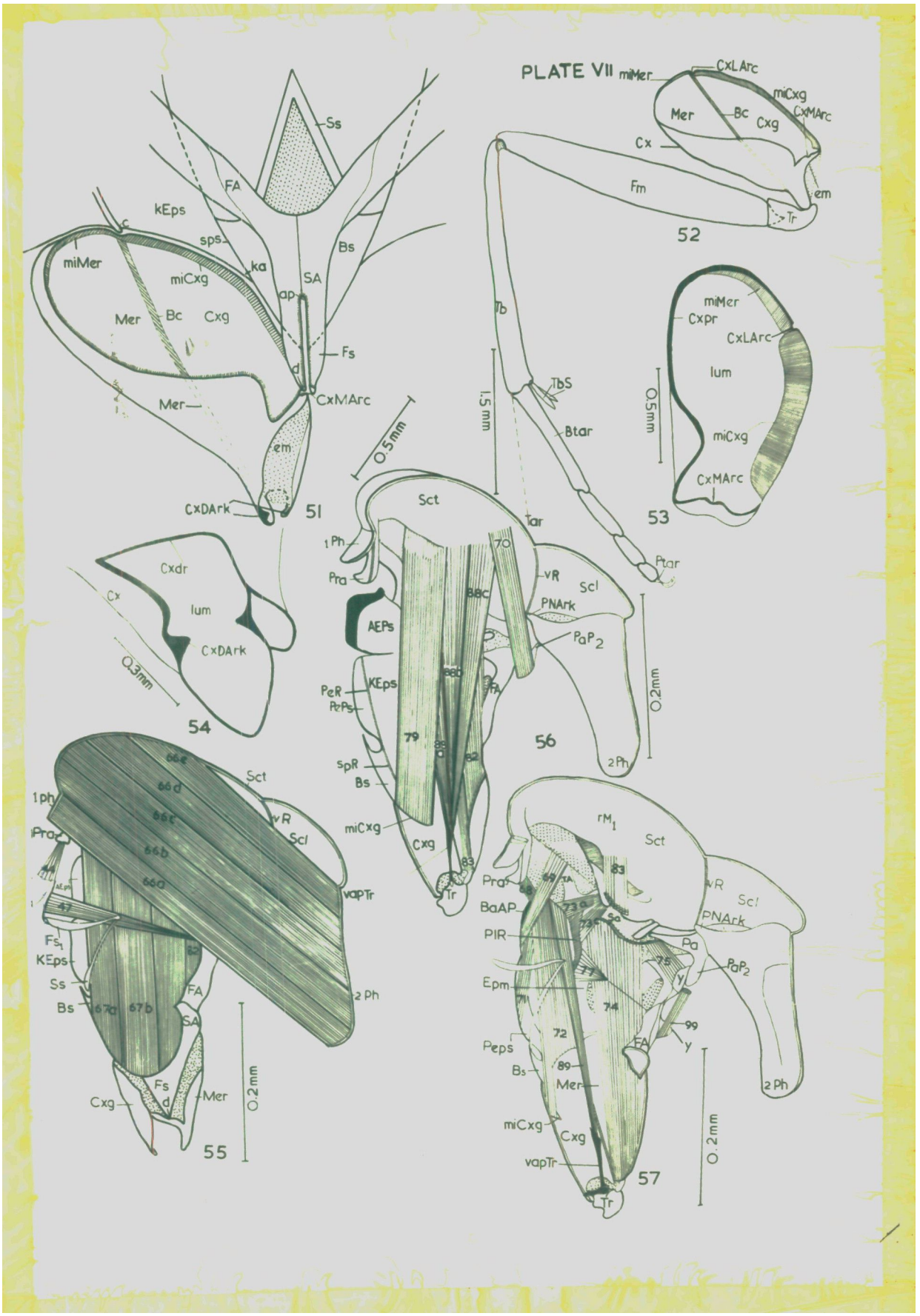
PLATE VII
miMer
CxLArc
miCxg
Mer
Bc
Cxg
CxMArc
Cx
Fm
em
Tr
52
Ss
FA
kEps
c
sps
Bs
miMer
ka
SA
miCxg
ap
Mer
Bc
Cxg
Fs
d
CxMArc
Mer
em
CxDArk
51
Tb
TbS
Btar
1.5 mm
0.5mm
miMer
Cxpr
CxLArc
lum
0.5mm
miCxg
CxMArc
53
Ptar
Sct
tar
1 Ph
70
Pra
vR
Scl
88c
PNArk
AEPs
PaP2
88d
PeR
KEps
PrPs
FA
79
89
82
0.2mm
56
2 Ph
spR
Bs
miCxg
Cxg
83
Tr
Cxdr
Cx
lum
CxDArk
0.3mm
54
66e
66d
66c
66b
66a
Sct
1 ph
Pra
vR
Scl
vapTr
47
Fs1
KEps
Ss
Bs
67a
67b
FA
SA
2 Ph
Fs
d
Mer
Cxg
0.2mm
55
rM1
Sct
Pra
69
TA
83
vR
Scl
BaAP
73a
73b
50
PNArk
PIR
Pa
75
PaP2
Epm
77
y
71
74
99
y
72
FA
Peps
89
Bs
Mer
2 Ph
miCxg
Cxg
vapTr
Tr
0.2mm
57

PLATE VIII

Thorax (contd.).

Fig. 58. Inner view of the lateral half of mesothorax with muscles of the fore-wing and the middle-leg.

Fig. 59. Inner view of the lateral half of middle-coxa with muscles.

Fig. 60. Inner view of the lateral half of middle-coxa with muscles of trochanter.

Fig. 61. Inner view of the lateral half of middle-coxa with muscles of the trochanter.

Fig. 62. Proximal rim of trochanter with muscles.

Fig. 63. Lateral view of metathorax.

Fig. 64. Inner view of the lateral half of metathorax.

Fig. 65. Sagittal section of meso, and meta-terga and the first abdominal tergum.

Fig. 66. Ventral view of metathorax.

Fig. 67. Ventral view of furcasternum and endosternum.

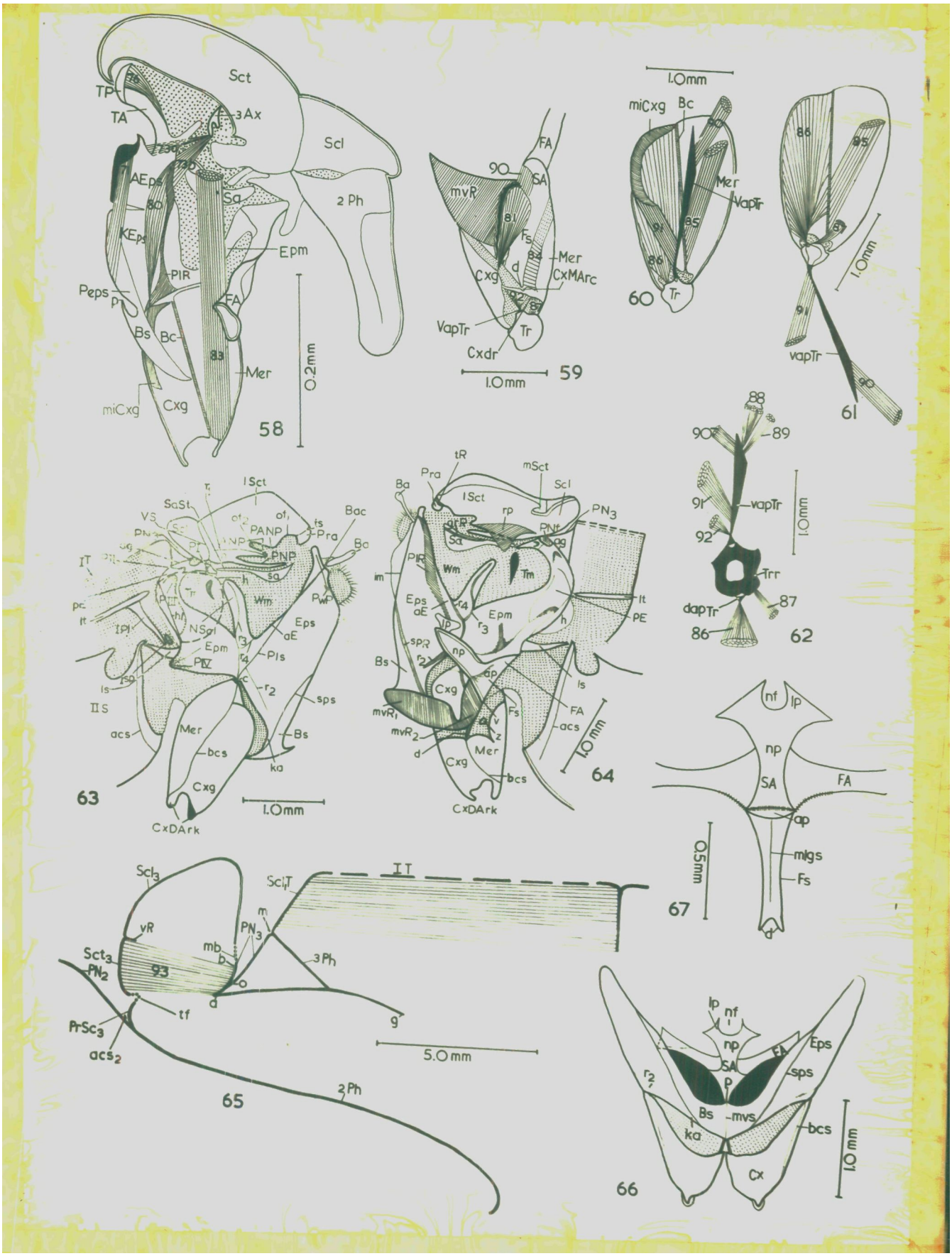
Sct
TP
TA
3Ax
Scl
2 Ph
AEps
Sa
KEps
Epm
PIR
Peps
FA
Bs
Bc
Mer
miCxg
Cxg
0.2mm
58
FA
90
SA
mvR
81
Fs
Mer
d
Cxg
CxMArc
VapTr
Tr
Cxdr
1.0mm
59
1.0mm
miCxg
Bc
Mer
VapTr
91
85
86
Tr
60
86
85
91
1.0mm
vapTr
90
61
88
90
89
91
vapTr
92
1.0mm
Trr
dapTr
87
86
62
tR
Pra
mSct
Ba
Scl
1Sct
PN3
rp
PNf
Sd
PIR
Wm
Tm
im
Eps
aE
r4
Epm
r3
lp
spR
r2
np
Bs
dp
ls
Cxg
FA
mvR1
Fs
mvR2
v
z
acs
d
Mer
Cxg
bcs
CxDArk
1.0mm
64
1Sct
SaSt
VS
PANP
PNP
Bac
Pra
Ba
IT
sg
h
Wm
Pwp
pc
lt
IPl
NSgl
Eps
aE
Epm
r3
r4
Pls
c
r2
sps
IIS
ls
acs
Mer
bcs
Bs
ka
Cxg
CxDArk
1.0mm
63
nf
lp
np
SA
FA
ap
0.5mm
mlgs
Fs
d
67
Scl3
Scl1
II
vR
m
PN3
mb
b
3Ph
Sct3
PN2
93
o
d
g
tf
PrSc3
acs2
5.0mm
2Ph
65
lp
nf
np
SA
Eps
FA
sps
r2
p
Bs
mvs
ka
bcs
Cx
1.0mm
66

PLATE IX

Thorax (contd.).

Fig. 68. Hind-leg.

Fig. 69. Inner view of the lateral half of metathorax with muscles of the hind-wing and the hind-leg.

Fig. 70. Inner view of the lateral half of metathorax with muscles of the hind-wing and the hind-leg.

Fig. 71. Inner view of the lateral half of metathorax with muscles of the hind-wing and the hind-leg.

Fig. 72. Inner view of the lateral half of metathorax with muscles of the hind-wing and the hind-leg.

Fig. 73. Inner view of the lateral half of hind-coxa with muscles of the hind-coxa and trochanter.

Fig. 74. Inner view of the lateral half of hind-coxa with muscles of the trochanter.

Fig. 75. Inner view of the lateral half of hind-coxa with muscles of the trochanter.

Fig. 76. Fore-wing base in relation to tergal margin.

Fig. 77. Fore-wing base in relation to pleural margin.

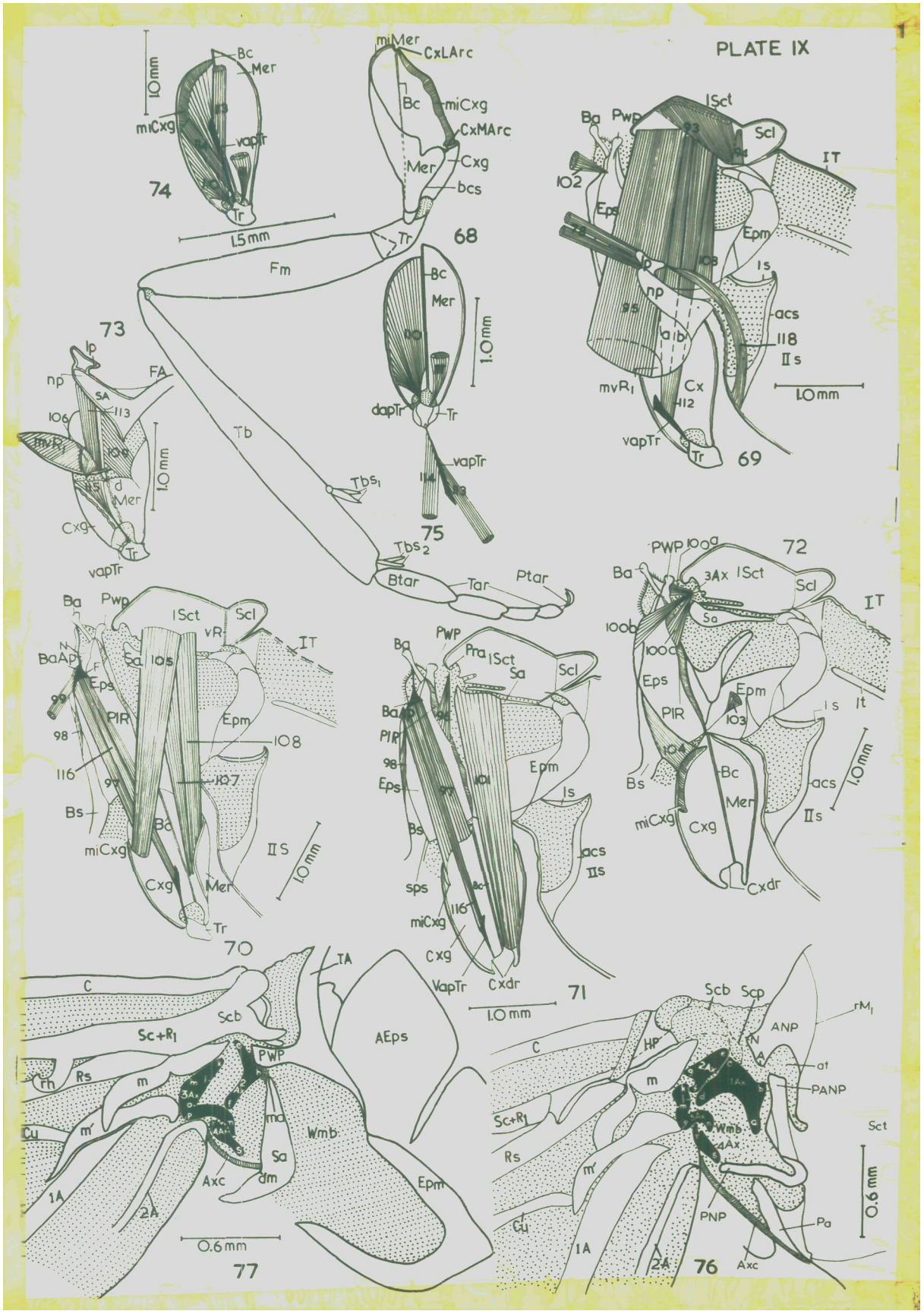
PLATE IX
74
Bc
Mer
miCxg
vapTr
Tr
1.0mm
68
miMer
CxLArc
Bc
miCxg
CxMArc
Mer
Cxg
bcs
Tr
1.5mm
Fm
Tb
73
lp
FA
np
SA
106
113
Mer
Cxg
Tr
vapTr
1.0mm
75
Bc
Mer
dapTr
Tr
vapTr
Tbs1
Tbs2
Btar
Tar
Ptar
69
ISct
Ba
Pwp
Scl
IT
102
Eps
Epm
Is
np
acs
118
IIs
mvR1
Cx
112
vapTr
Tr
1.0mm
72
PWP
100a
Ba
3Ax
ISct
Scl
IT
Sa
100b
100c
Eps
Epm
PlR
103
Is
It
Bs
Bc
acs
miCxg
Mer
IIs
Cxg
Cxdr
1.0mm
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Ba
Pwp
ISct
Scl
vR
IT
BaAp
Sa
105
Eps
PlR
Epm
108
98
116
107
Bs
Ba
miCxg
IIS
Cxg
Mer
Tr
1.0mm
71
PWP
Ba
Pra
ISct
Sa
Scl
BaAp
PlR
98
Eps
101
Epm
Is
Bs
acs
IIs
sps
116
miCxg
Cxg
VapTr
Cxdr
1.0mm
77
C
Scb
Sc+R1
TA
AEps
PWP
rh
Rs
m
Cu
m'
1A
2A
Axc
ma
Wmb
Sa
dm
Epm
0.6mm
76
Scb
Scp
rM1
ANP
C
HP
N
A
at
m
PANP
Sc+R1
Wmb
Sct
Rs
m'
Cu
PNP
Pa
1A
2A
Axc
0.6mm

PLATE X

Thorax (contd.).

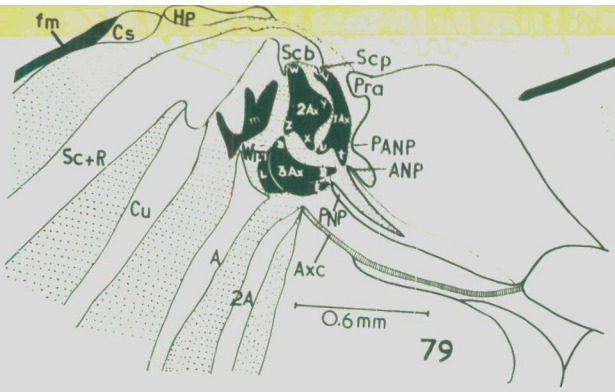
Fig. 78. Fore-wing.

Fig. 79. Hind-wing base in relation to tergal margin.

Fig. 80. Hind-wing base in relation to pleural margin.

Fig. 81. Hind-wing.

PLATE X



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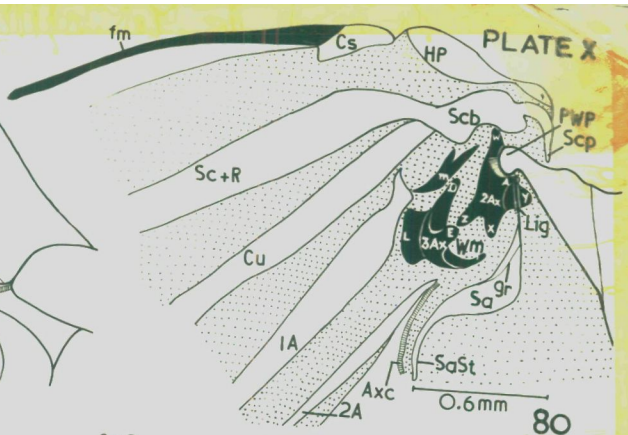

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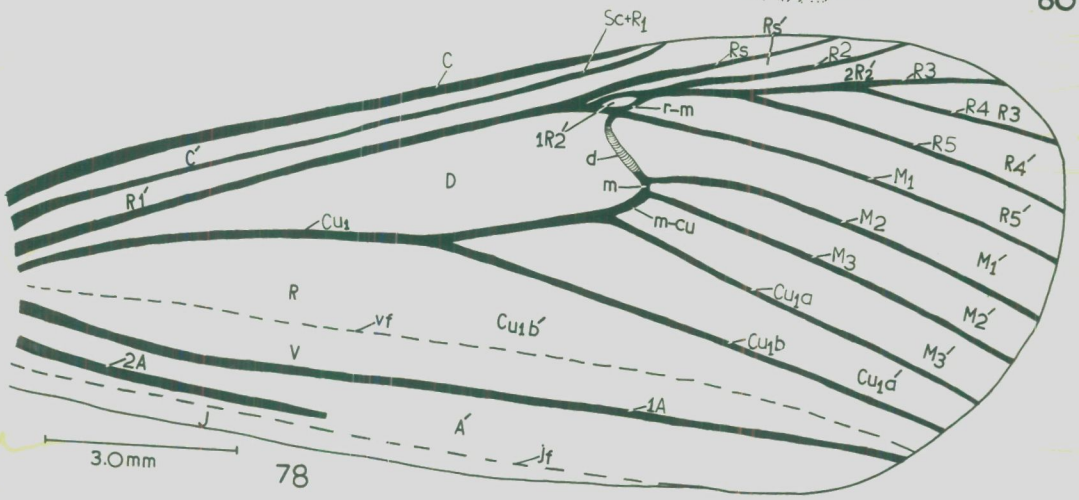

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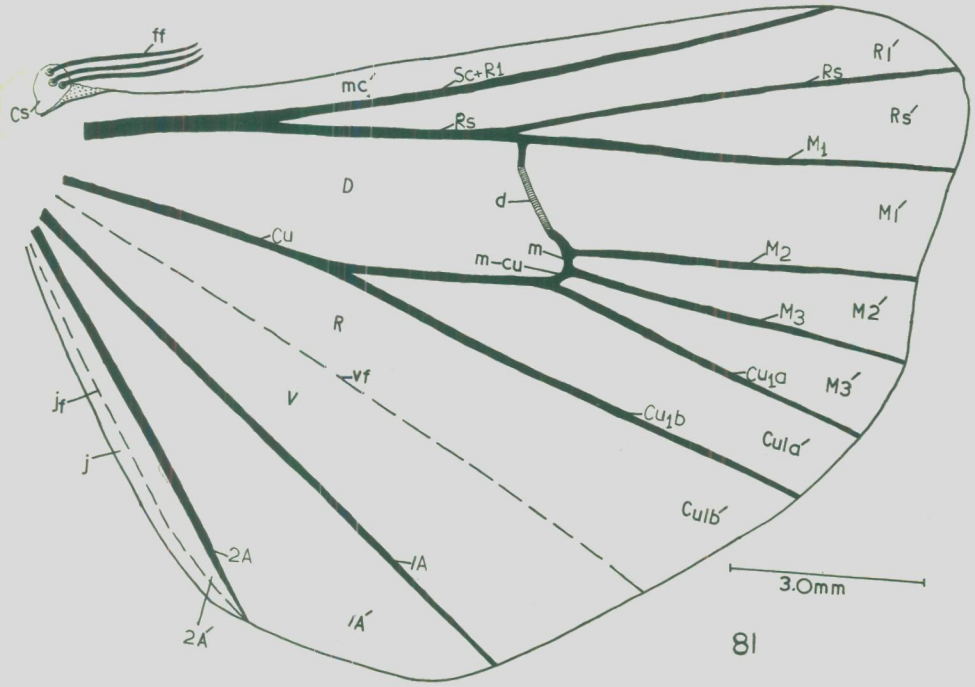


81

PLATE XI

Abdomen.

Fig. 82. Inner view of lateral half of abdomen (pre-genital region).

Fig. 83. Outer view of I Tergum with a portion of its pleuron.

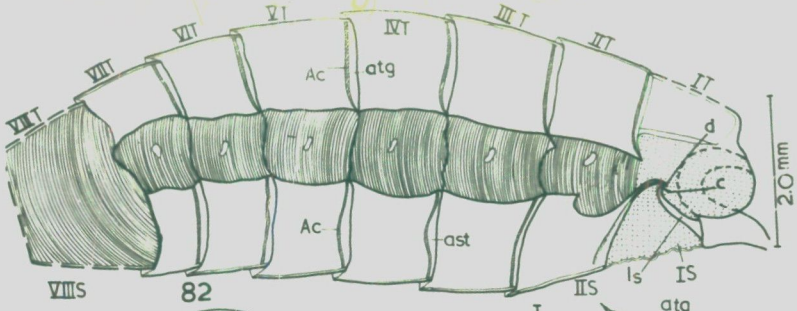
Fig. 84. Inner view of metatergum and I abdominal tergum with a portion of the metaspineron.

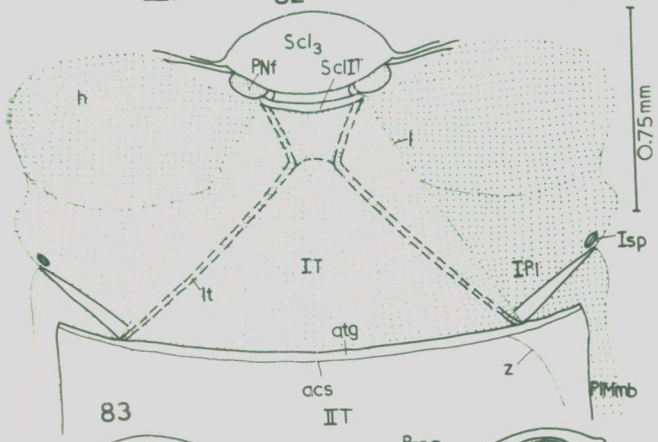
Fig. 85. Inner view of II Tergum.

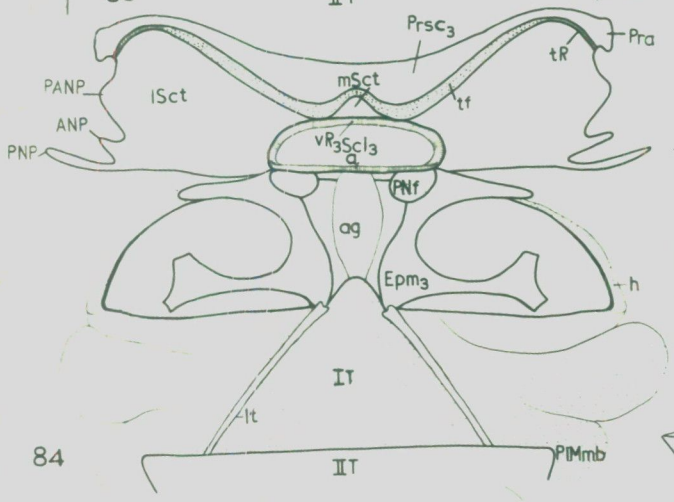
Fig. 86. Inner view of III - VII terga of female.

Fig. 87. Inner view of VII & VIII terga of male.

PLATE XI


VI
VII
IV
III
II
VIII
I
Ac
atg
d
c
2.0 mm
Ac
ast
VIIIS
82
IIS
ls
IS


Scl3
PNf
SclIT
h
l
0.75 mm
IT
IPl
Isp
lt
atg
acs
z
PlMmb
83
IIT


Prsc3
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PANP
lSct
mSct
tf
ANP
PNP
vR3Scl3
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PNf
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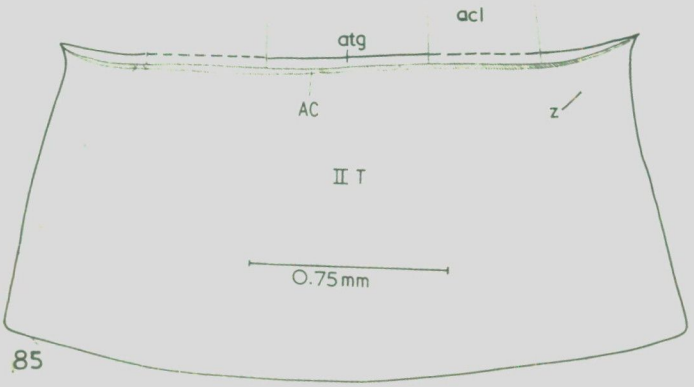
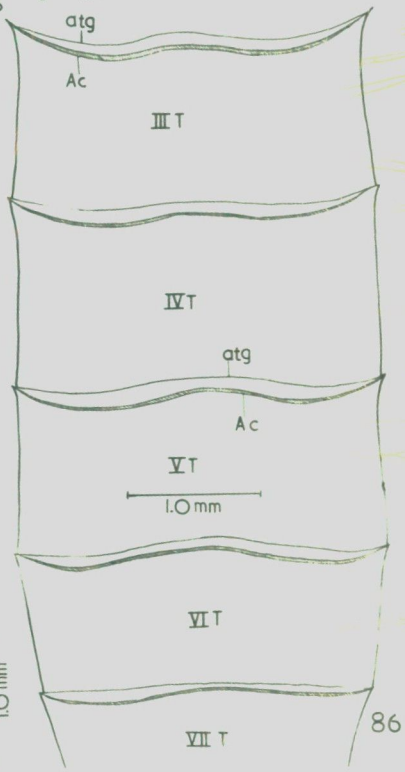
Epm3
h
1.0 mm
IT
lt
84
IIT
PlMmb


acl
atg
AC
z
II T
0.75 mm
85


atg
Ac
III T
IV T
atg
Ac
V T
1.0 mm
VI T
VII T
86

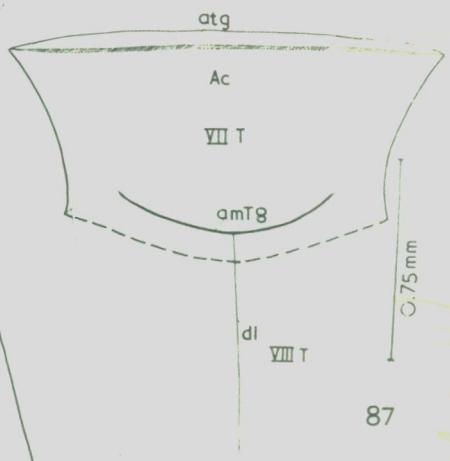

atg
Ac
VII T
amT8
0.75 mm
dl
VIII T
87

PLATE XXI

Abdomen (contd.)

Fig. 88. Inner view of VII & VIII terga of female with pseudo-ovipositor.

Fig. 89. Outer view of II & VI sterna.

Fig. 90. Outer view of VII sternum of female.

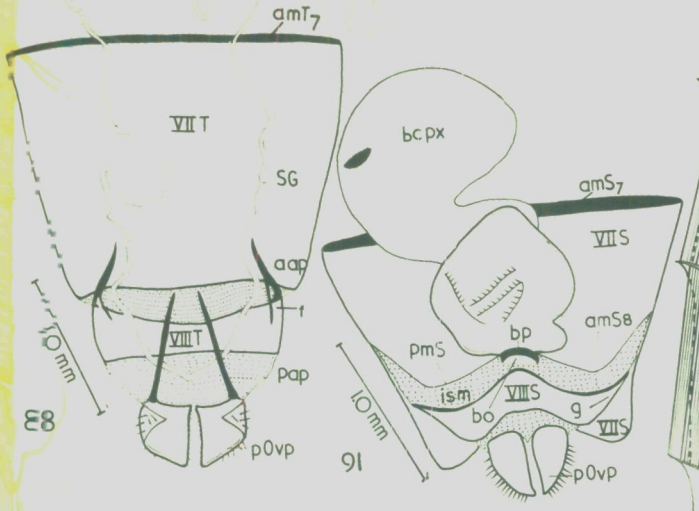
Fig. 91. Outer view of VII & VIII sterna of female with pseudo-ovipositor.

Fig. 92. Diagrammatic T.S. of abdomen showing grouping of muscles.

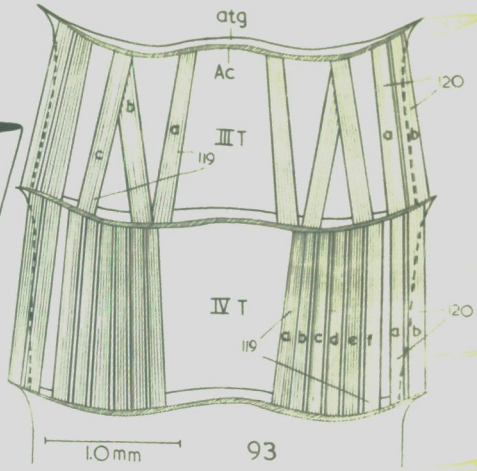
Fig. 93. Inner view of III & IV terga with internal dorsal muscles.

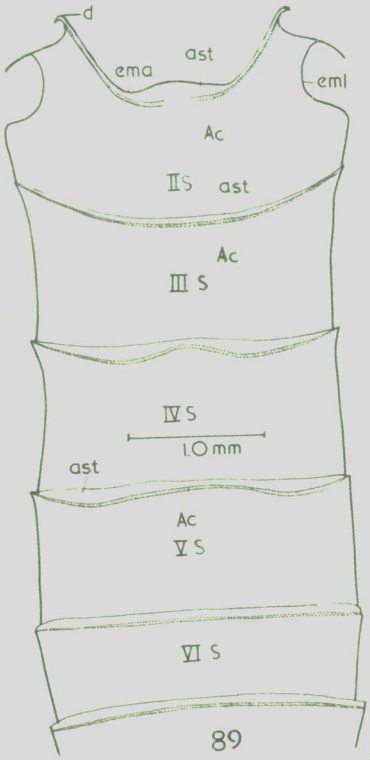
Fig. 94. Inner view of II tergum with internal dorsal muscles.

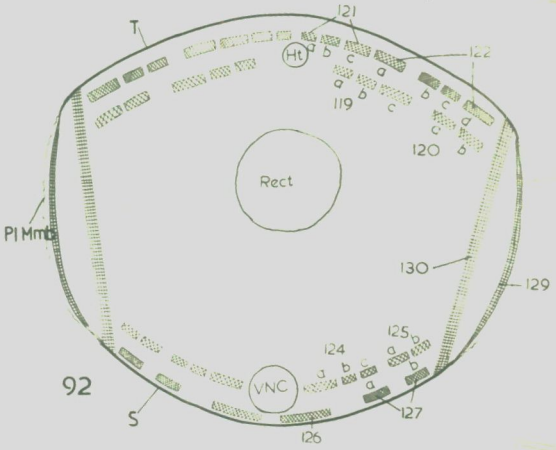
PLATE XII


amT7
VII T
SG
aap
f
VIII T
pap
p0vp
1.0 mm
88

bc px
amS7
VII S
amS8
bp
pmS
ism
VIII S
bo
g
VIII S
p0vp
1.0 mm
91


atg
Ac
III T
119
120
IV T
119
120
1.0 mm
93


d
ema
ast
eml
Ac
II S
ast
Ac
III S
IV S
1.0 mm
ast
Ac
V S
VI S
89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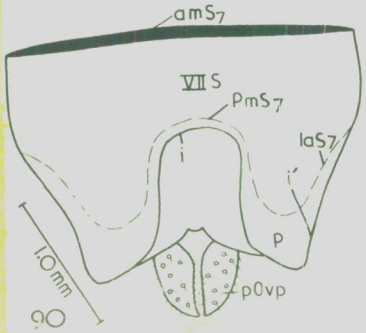
121
Ht
122
119
120
Rect
Pl Mm
130
129
125
124
VNC
127
126
92
S


amS7
VII S
PmS7
laS7
i
p
p0vp
1.0 mm
90

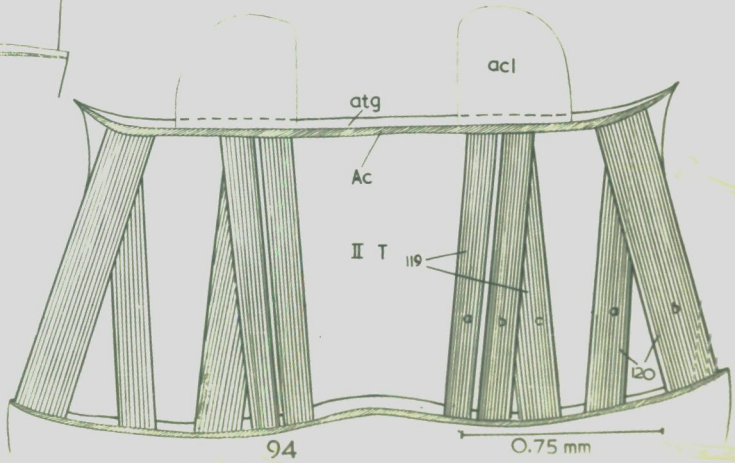

acl
atg
Ac
II T
119
120
94
0.75 mm

PLATE XLIX

Abdomen (contd.)

Fig. 95. Inner view of VI tergum with muscles.

Fig. 96. Inner view of III & IV terga with external dorsal muscles.

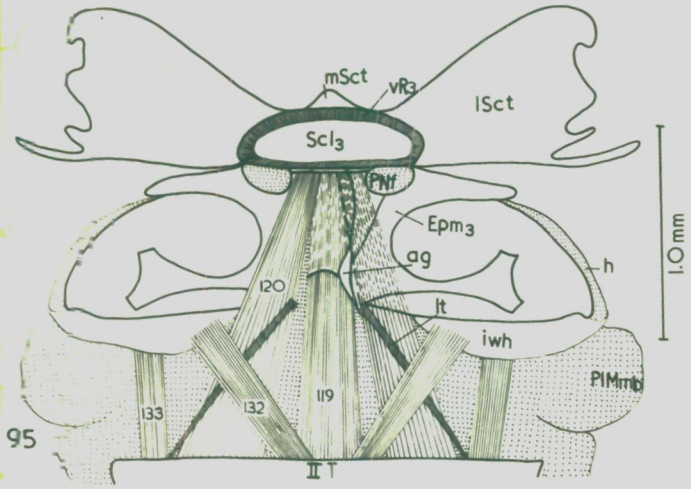
Fig. 97. Inner view of II tergum with external dorsal muscles.

Fig. 98. Inner view of lateral half of VII & VIII segments with dorsal, ventral and tergo-sternal muscles.

Fig. 99. Inner view of lateral half of VII & VIII segments with dorsal and ventral muscles.

Fig. 100. Inner view of II - V sterna with internal ventral muscles.

PLATE XIII



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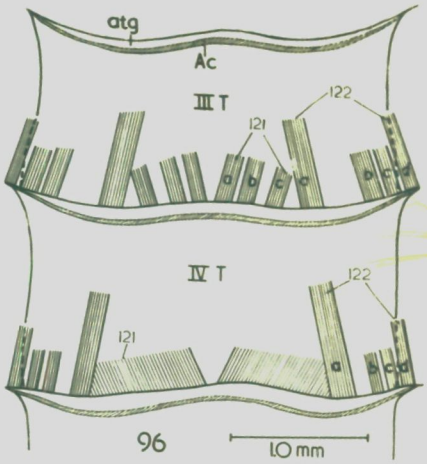

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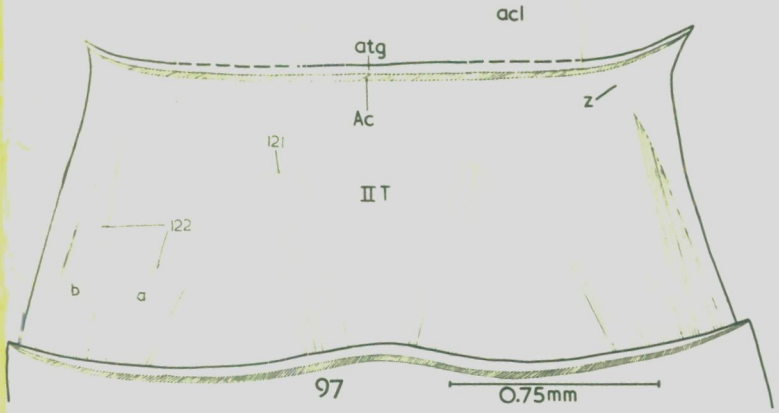

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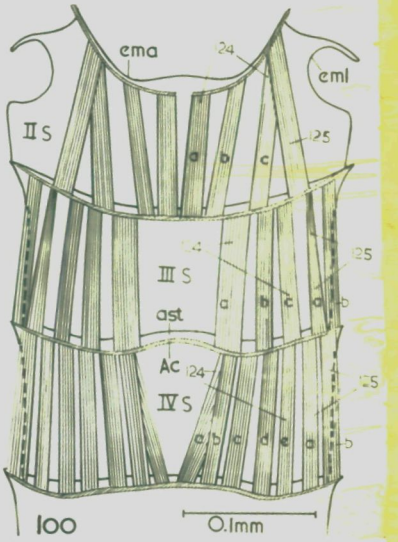

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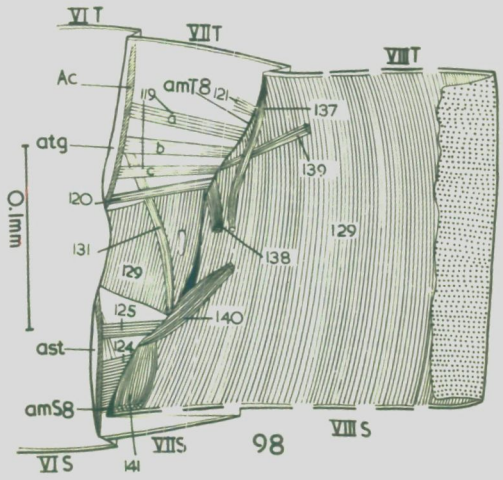

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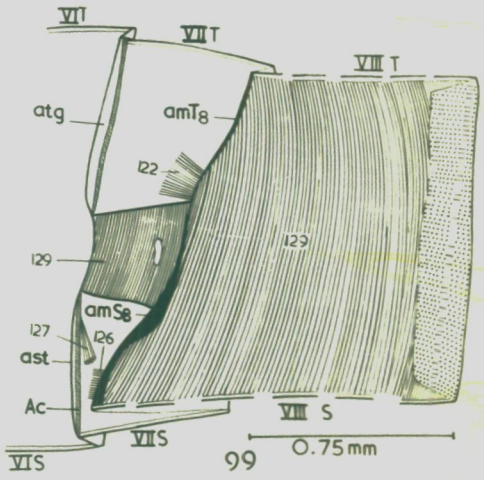


99

PLATEx XV

Abdomen (contd.).

Fig. 101. Inner view of II -IV sterna with external ventral muscles.

Fig. 102. Lateral view of VIII segment with muscles.

Fig. 103. Inner view of lateral half of II-V segments with muscles.

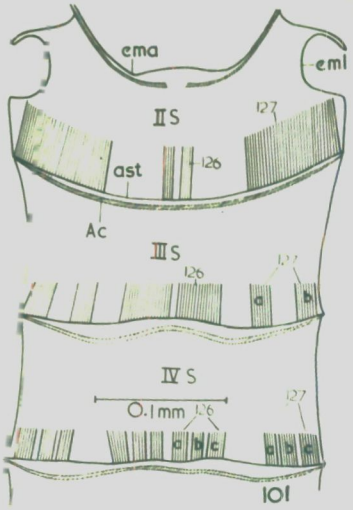
Fig. 104. Dorsal view of male genitalia.

Fig. 105. Ventral view of male genitalia.

Fig. 106. Lateral view of male genitalia.

Fig. 107. Inner view of the paramere.

PLATE XIV



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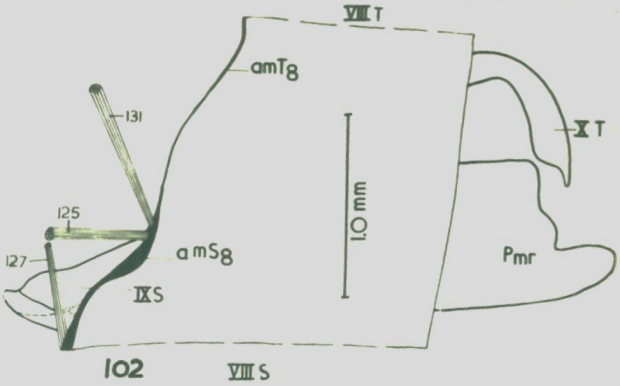

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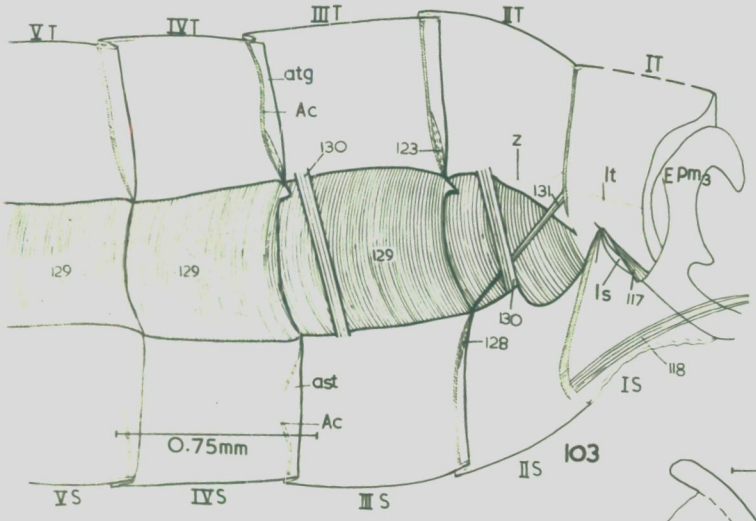

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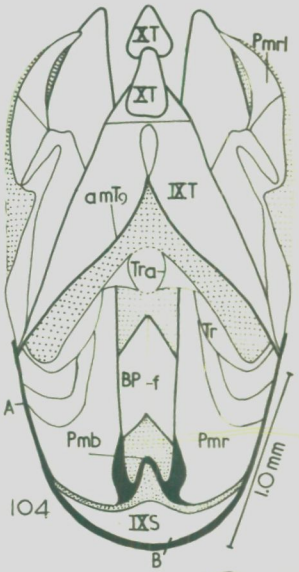

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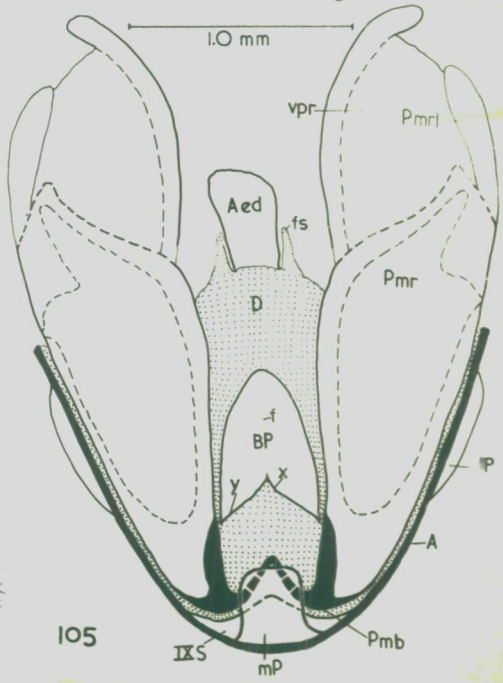

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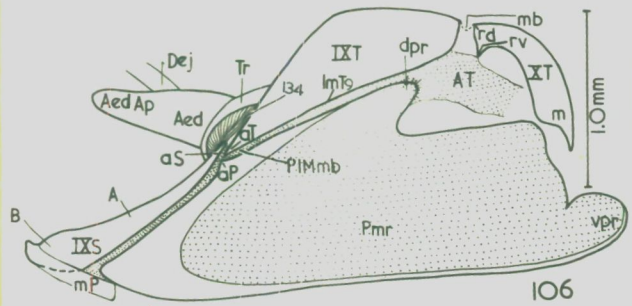

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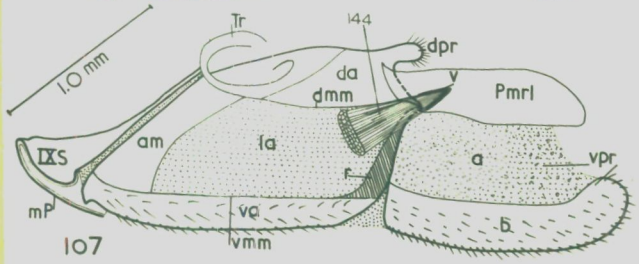


107

PLATE XV

Abdomen (contd.)

Fig. 108. Inner view of basal plate and parameres with muscles.

Fig. 109. Inner view of the ventral half of the endeagus.

Fig. 110. Lateral view of male genitalia with muscles.

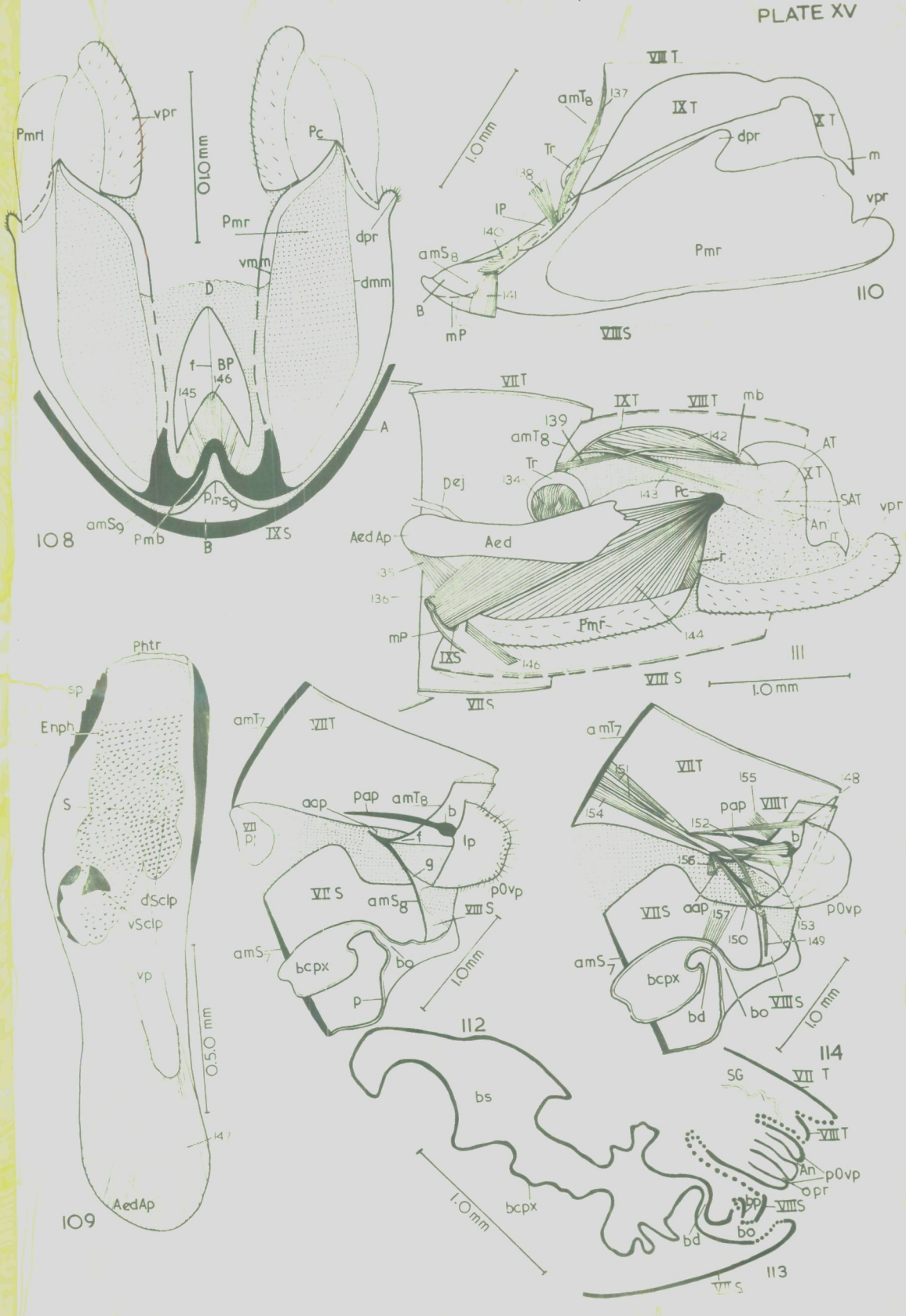
Fig. 111. Inner view of lateral half of male genitalia with muscles.

Fig. 112. Inner view of lateral half of VII & VIII segments and external female genitalia.

Fig. 113. Sagittal section of external female genitalia.

Fig. 114. Inner view of lateral half of female genitalia with muscles.

PLATE XV


Pmr1
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Pc
Pmr
dpr
vmm
dmm
D
BP
146
145
A
Pirsg
amSg
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B
IX S
108
VIII T
amT8
137
IX T
X T
Tr
dpr
m
vpr
138
IP
140
amS8
Pmr
B
141
mP
VIII S
110
VII T
IX T
VIII T
mb
139
amT8
142
AT
Tr
134
X T
Dej
143
Pc
SAT
vpr
An
Aed Ap
Aed
r
135
136
mP
Pmr
144
IX S
146
111
VIII S
VII S
1.0 mm
Phtr
sp
Enph
S
dSclp
vSclp
vp
0.5 0 mm
147
AedAp
109
amT7
VIII T
aap
pap
amT8
b
f
lp
g
VII S
amS8
VIII S
pOvp
amS7
bcpx
bo
p
1.0mm
112
a mT7
VIII T
151
155
148
154
pap
VIII T
152
b
156
VIII S
aap
157
pOvp
153
150
149
amS7
bcpx
bd
bo
VIII S
1.0 mm
114
SG
VII T
bs
VIII T
An
pOvp
opr
1.0 mm
bcpx
pp
VIII S
bd
bo
113
VII S

PLATE XVI

Internal Anatomy.

Fig. 115. Digestive and Excretory Systems.

Fig. 116. T.S. of oesophagus.

Fig. 117. T.S. of crop.

Fig. 118. A portion of T.S.of crop (highly magnified).

Fig. 119. L.S. through the junction of provehtriculus and mesenteron showing stomodaeal valve.

Fig. 120. T.S. of mesenteron.

Fig. 121. L.S. of mesenteron with digestive enzymes oozing out, (a portion highly magnified).

Fig. 122. L.S. of mesenteron showing sloughing off of the old epithelium (a portion highly magnified).

Fig. 123. L.S. through the junction of mesenteron and proctodeaeum showing proctodaeal valve.

Fig. 124. T.S. of intestine.

PLATE XVI

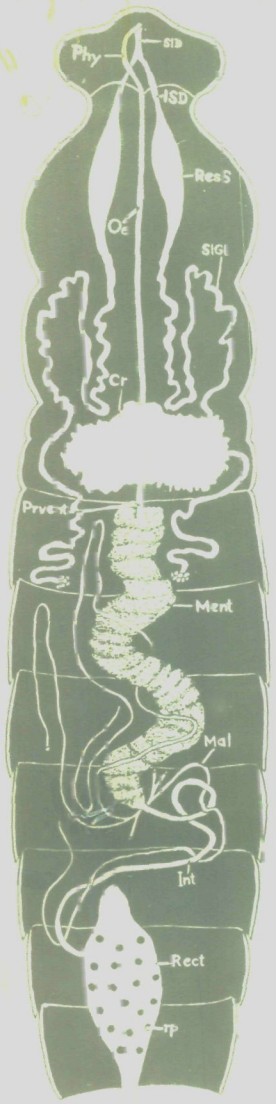


PLATE XVII

Internal Anatomy (contd.)

Fig. 125. T.S. of rectum passing through a monopapillar type of rectal papilla.

Fig. 126. T.S. of rectum passing through dipapillar type of rectal papilla.

Fig. 127. T.S. of salivary gland.

Fig. 128. T.S. of salivary duct.

Fig. 129. T.S. of malpighian tubule.

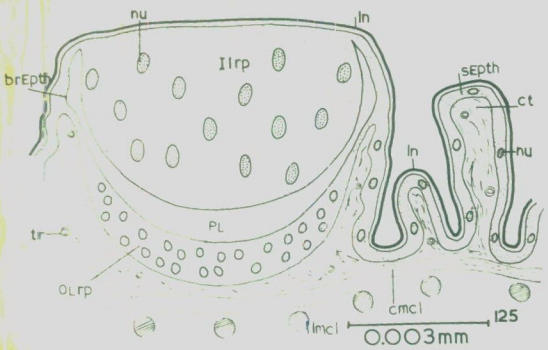
Fig. 130. Dorsal vessel and dorsal diaphragm .

Fig. 131. Sagittal section of the heart passing through one ostium.

Fig. 132. Dorsal view of ventral diaphragm with its muscles.

Fig. 133. Diagrammatic T.S. of the abdomen showing subdivisions of the body cavity.

PLATE XVII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sEpth
ct
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OLrp
cmcl
lmcl
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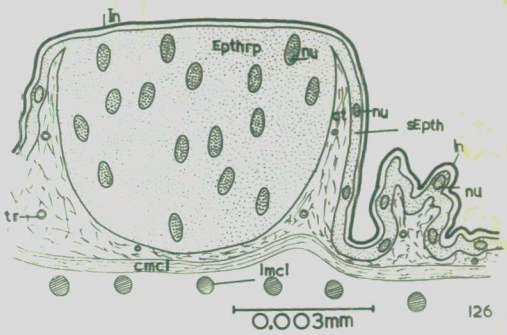
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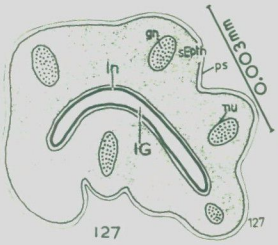
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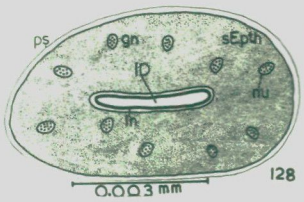
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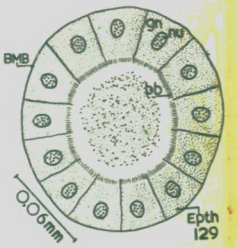
gn
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BMB
bb
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Epth
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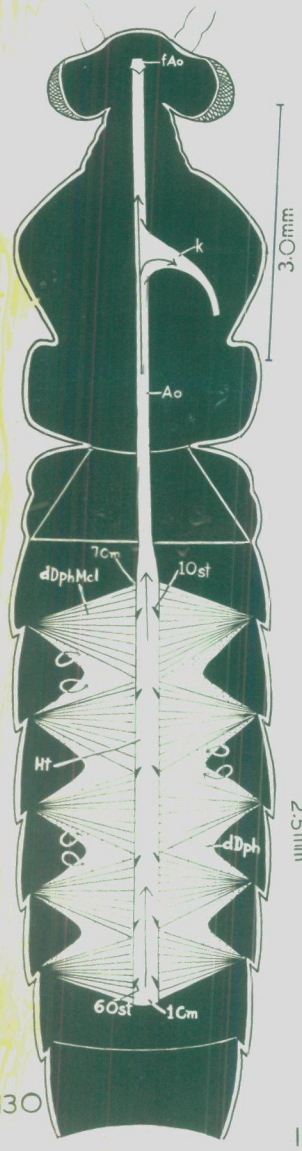
fAo
k
3.0mm
Ao
7Cm
dDphMcl
10st
Ht
dDph
60st
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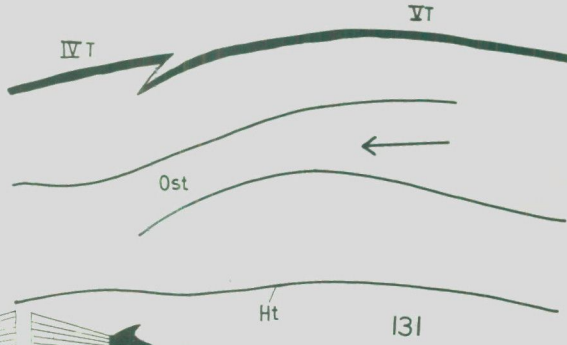
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Ht
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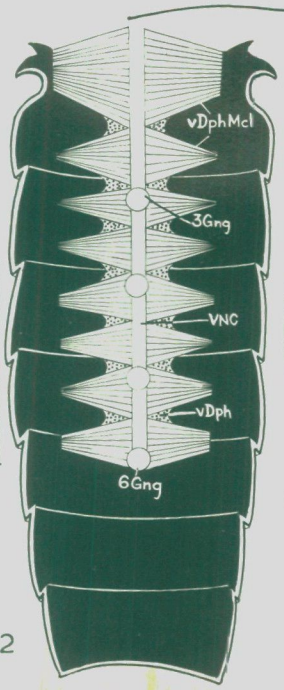
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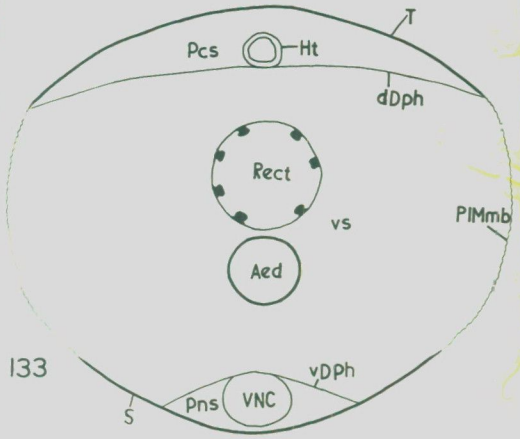
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Rect
vs
PlMmb
Aed
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S
Pns
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PLATE XVIII

Internal Anatomy (contd.)

Fig. 134. Outer view of first thoracic spiracle.

Fig. 135. Inner view of first thoracic spiracle with muscle.

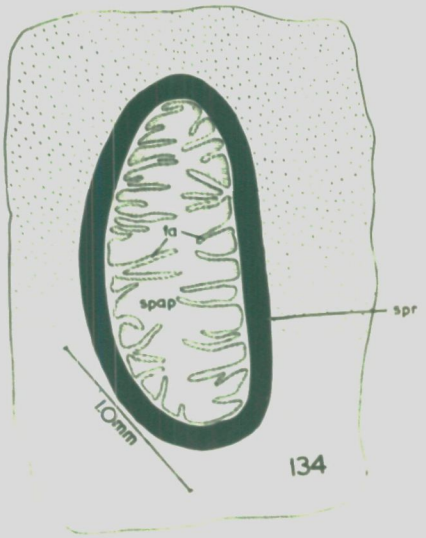
Fig. 136. Outer view of second thoracic spiracle with muscle.

Fig. 137. Outer wall of the atrium of the second thoracic spiracle(diagrammatic).

Fig. 138. Inner wall of the atrium of second thoracic spiracle (diagrammatic).

Fig. 139. Inner view of the fifth abdominal spiracle with muscle.

PLATE XVIII



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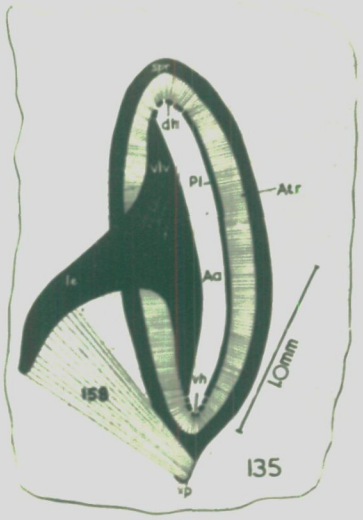

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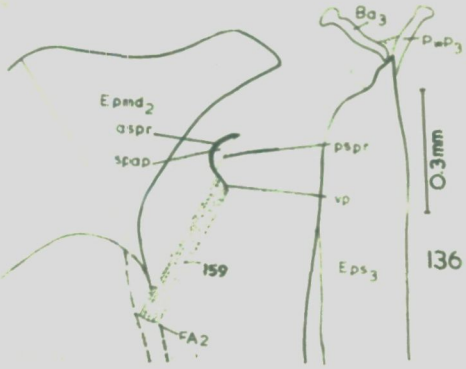

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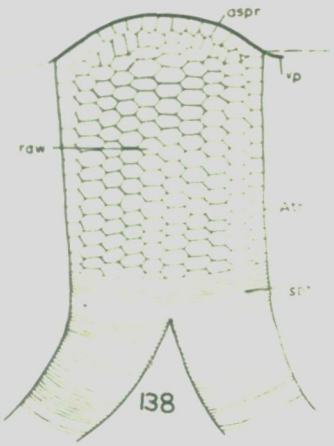

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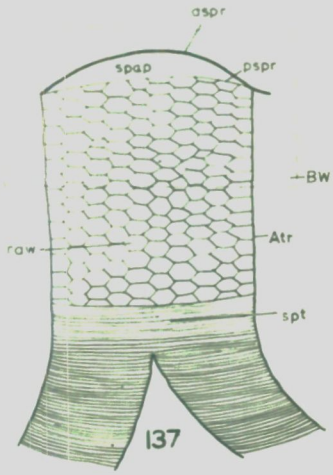

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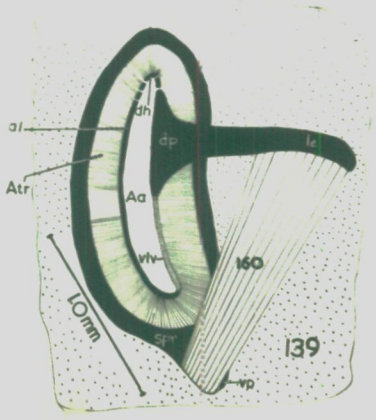

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PLATE XIX

Internal Anatomy (contd.).

Fig. 140. Dorsal view of tracheae and air sacs in the head.

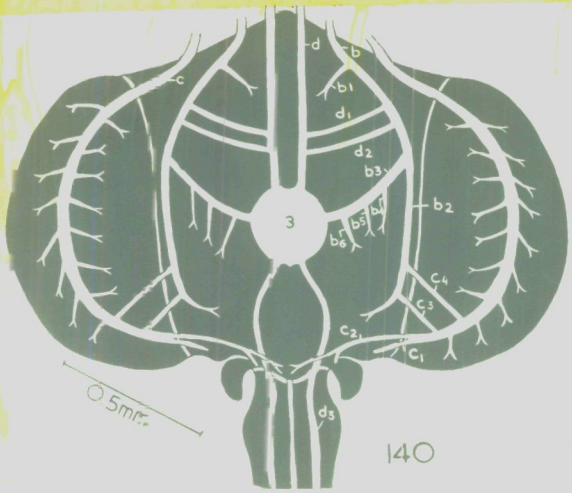
Fig. 141. Lateral view of tracheae and air sacs in the head.

Fig. 142. Dorsal view of the respiratory system of the male.

Fig. 143. Dorsal view of the respiratory system of the male.

Fig. 144. Dorsal view of the respiratory system in the VII - X abdominal segments of the female.

PLATE XIX



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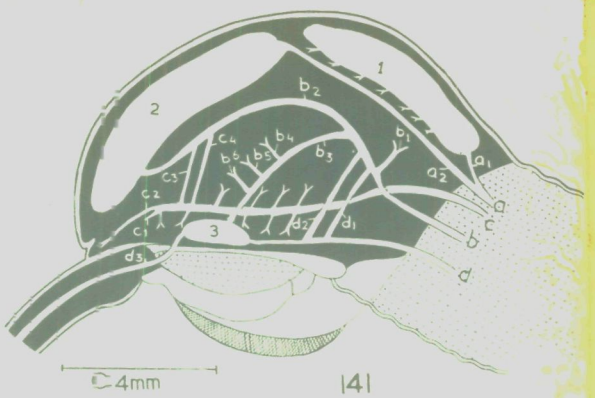

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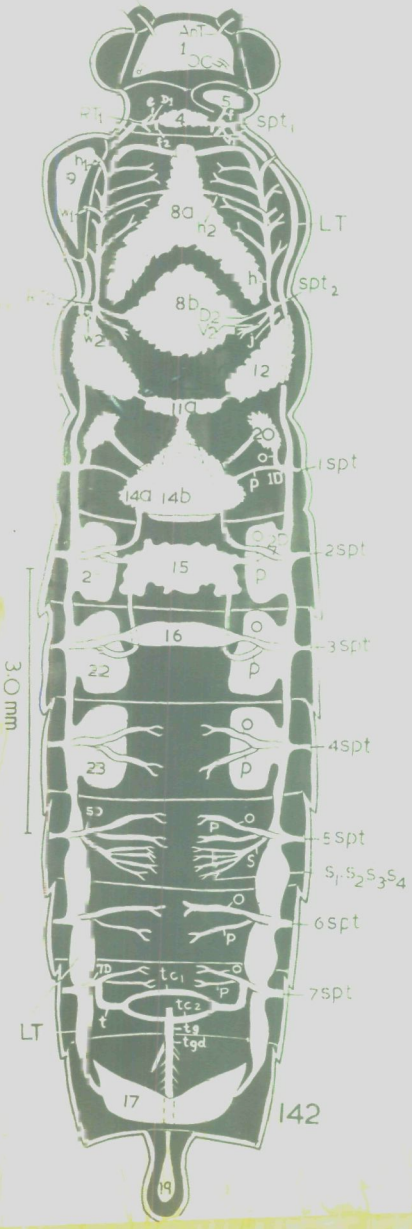

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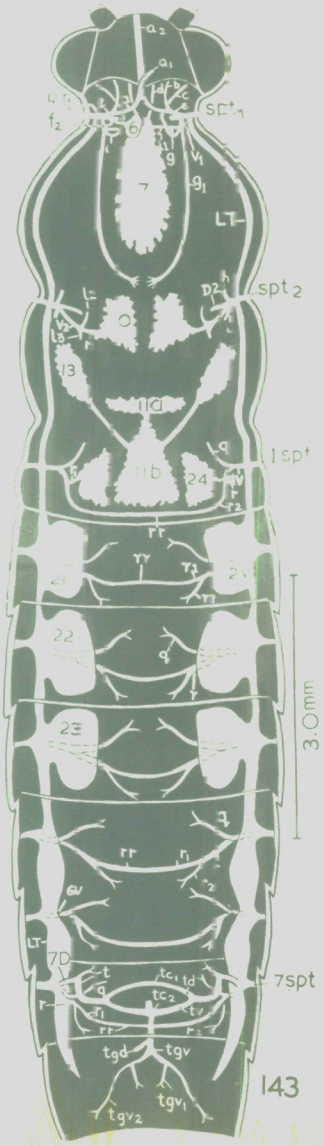

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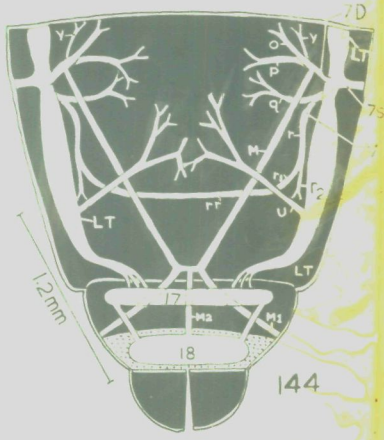


144

PLATE XX

Internal Anatomy (contd.).

Fig. 145. Male reproductive system.

Fig. 146. L.S. of a portion of testis.

Fig. 147. T.S. of vas deferens.

Fig. 148. T.S. of a portion of seminal vesicle.

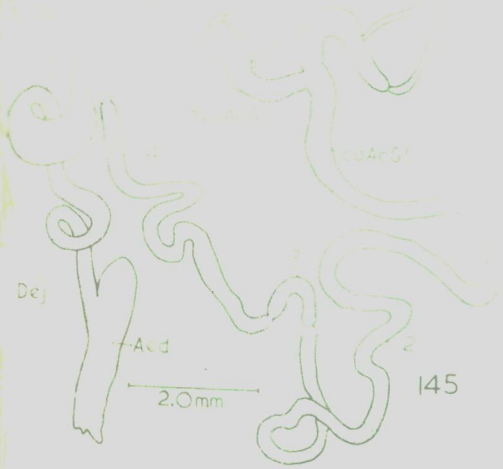
Fig. 149. T.S. of seminal duct.

Fig. 150. T.S. of accessory gland of male.

Fig. 151. T.S. of reservoir of accessory gland.

Fig. 152. T.S. of common duct of accessory gland (first portion).

PLATE XX



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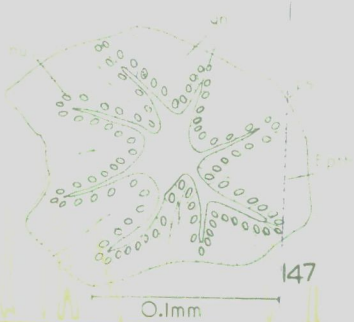

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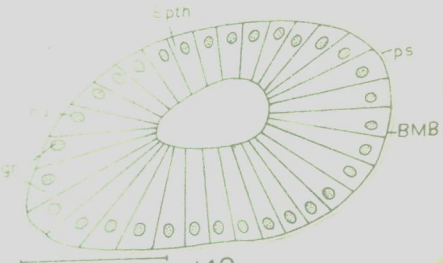

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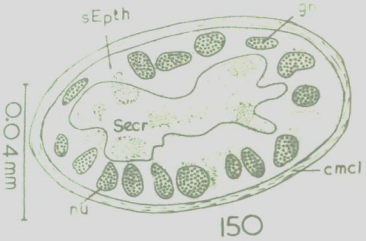

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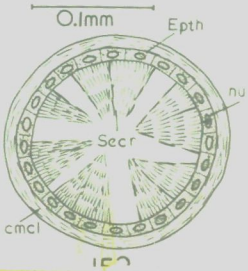


PLATE XXI

Internal Anatomy (contd.).

Fig. 153. T.S. of common duct of accessory gland (second portion).

Fig. 154. T.S. of common duct of accessory gland (third portion).

Fig. 155. T.S. of common duct of accessory gland (fourth portion).

Fig. 156. T.S. of ejaculatory duct.

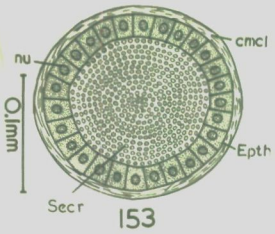
Fig. 157. L.S. of bulbous ejaculatorius.

Fig. 158. T.S. of ejaculatory duct near its entrance into the aedeagus.

Fig. 159. Female reproductive system.

Fig. 160. T.S. of a portion of the germarium.

PLATE XXI



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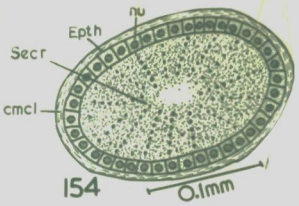

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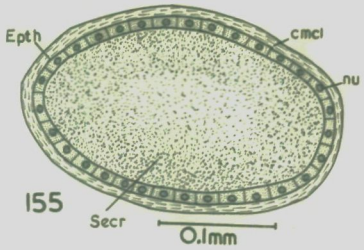

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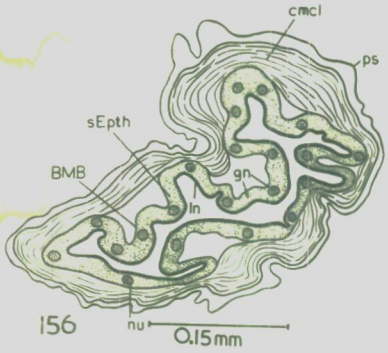

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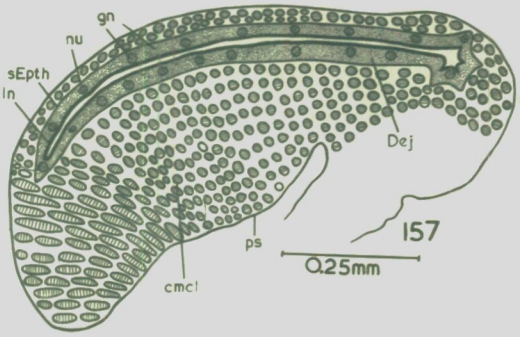

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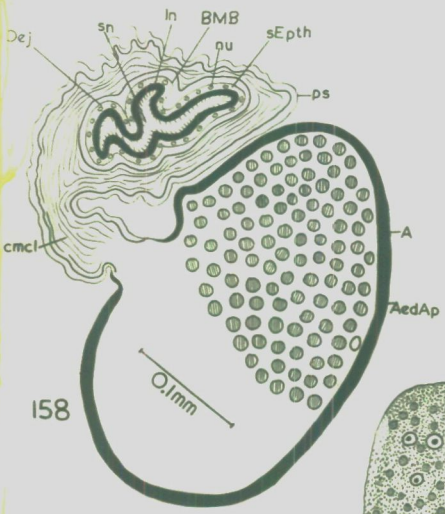

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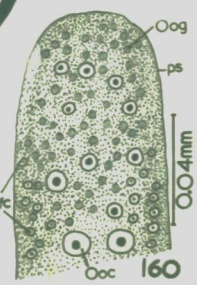

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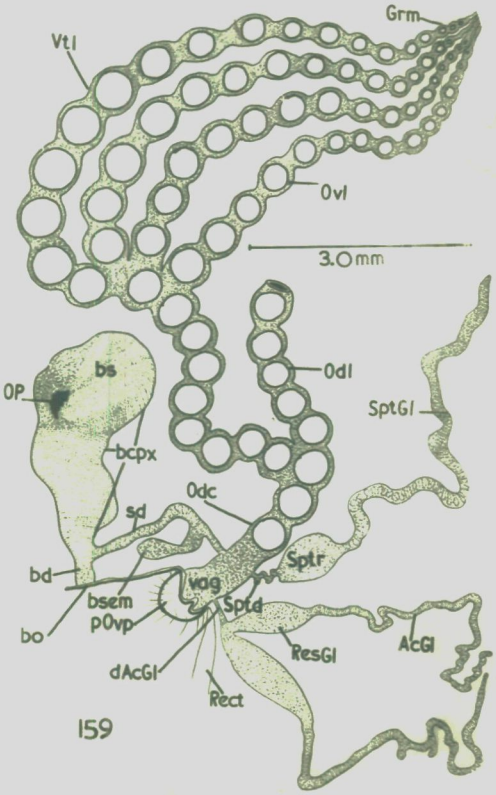

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PLATE XXII

Internal Anatomy (contd.).

Fig. 161. L.S. of a portion of vitellarium.

Fig. 162. T.S. of lateral oviduct.

Fig. 163. T.S. of anterior region of vagina.

Fig. 164. T.S. of posterior region of vagina.

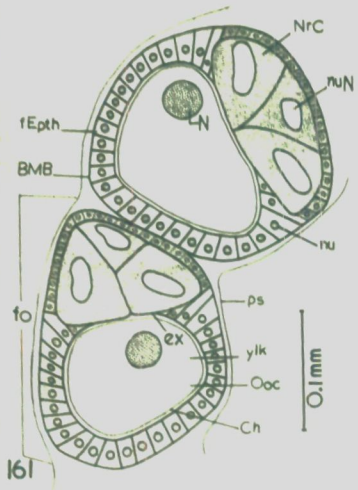
Fig. 165. T.S. of spermathecal gland.

Fig. 166. T.S. of spermathecal reservoir.

Fig. 167. T.S. of spermathecal duct.

Fig. 168. T.S. of bursal sac.

PLATE XXII



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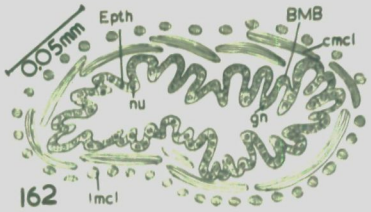

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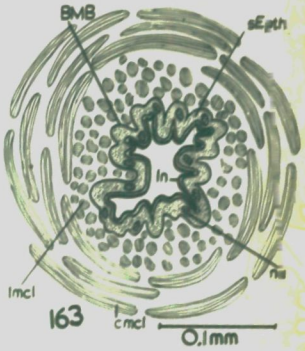

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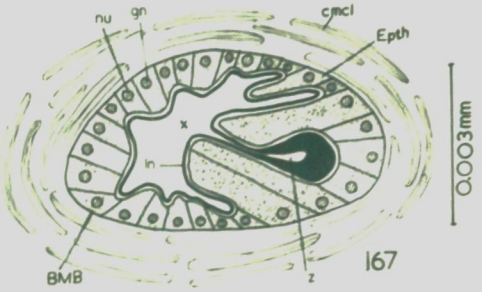

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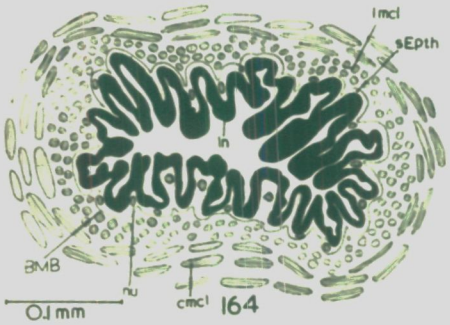

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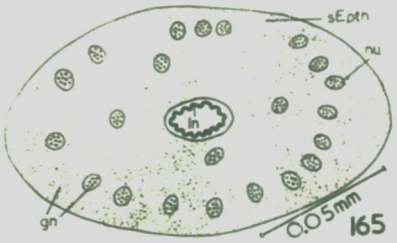

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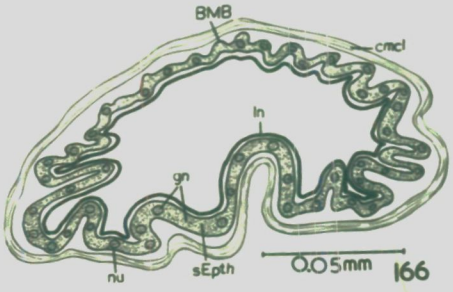

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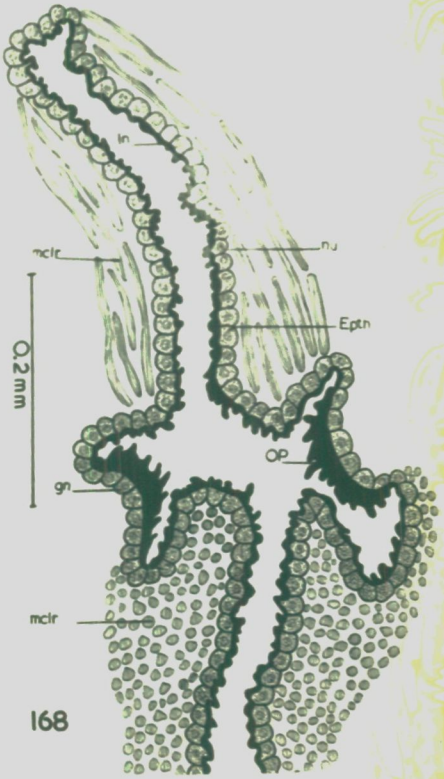

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PLATE XXIII

Internal Anatomy (contd.).

Fig. 169. T.S. of bursal duct.

Fig. 170. T.S. of seminal duct near its opening into the bursa copulatrix.

Fig. 171. T.S. of diverticulum of seminal duct.

Fig. 172. T.S. of accessory gland of female.

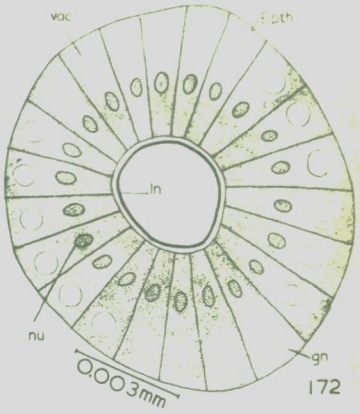
Fig. 173. T.S. of reservoir of accessory gland.

Fig. 174. T.S. of common duct of accessory glands.

Fig. 175. T.S. of attractant gland.

PLATE XXIII

169



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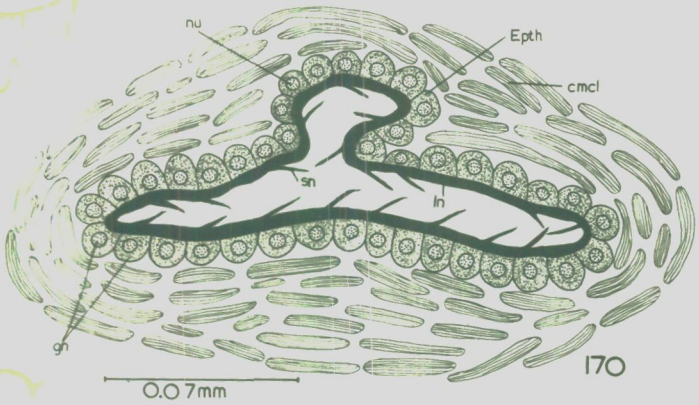

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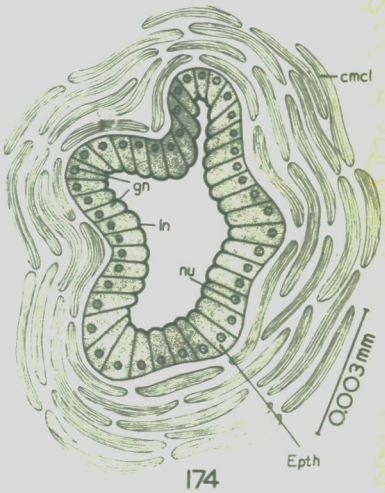

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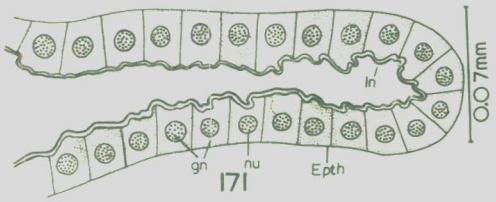

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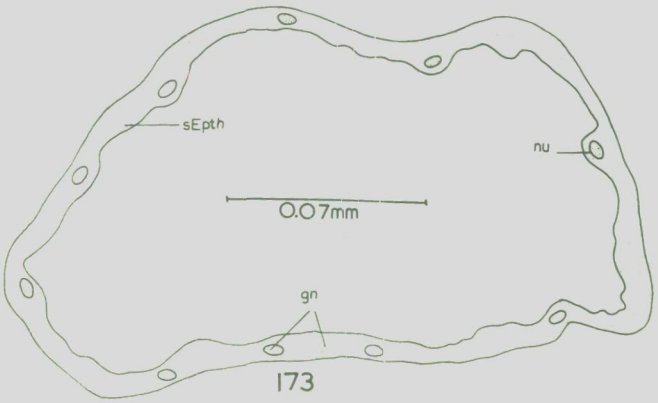

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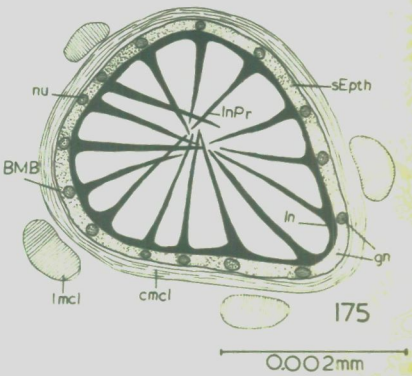

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PLATE XXIV

Internal Anatomy (contd).

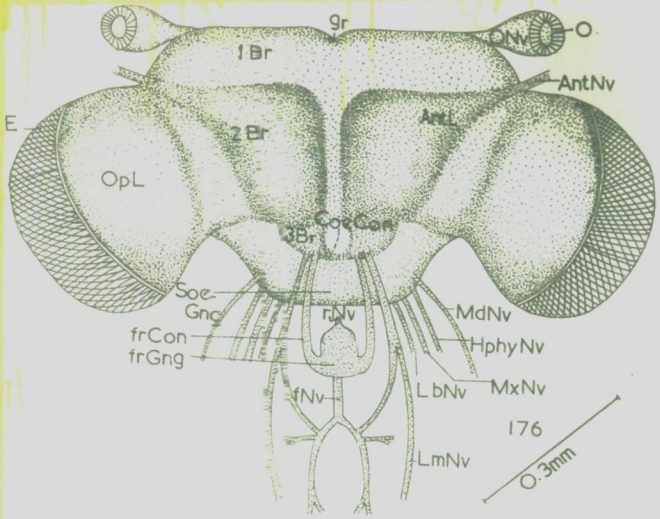
Fig. 176. Anterior view of the brain and suboesophageal ganglion with their nerves.

Fig. 177. General view of the Nervous system.

Fig. 178. Nerves of the terminal abdominal ganglion of the female.

Fig. 179. Stomodaeal Nervous System.

PLATE XXIV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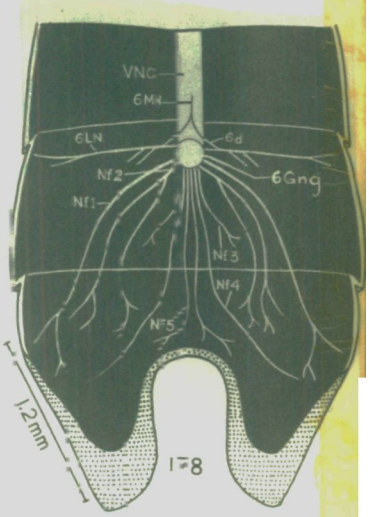
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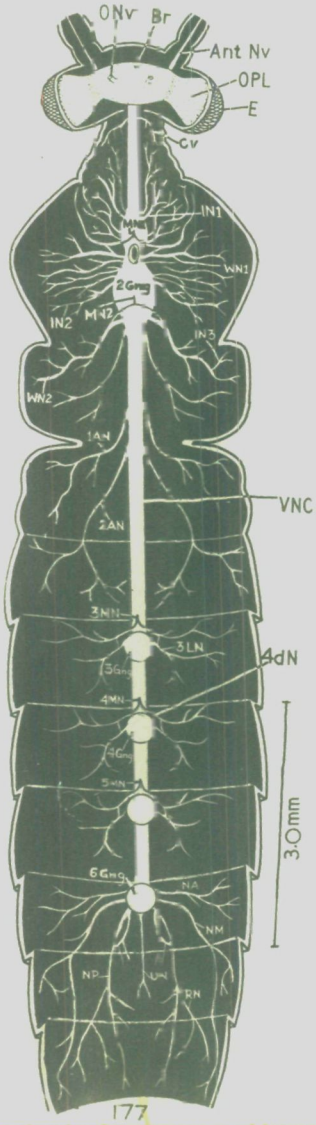
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2AN
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RN
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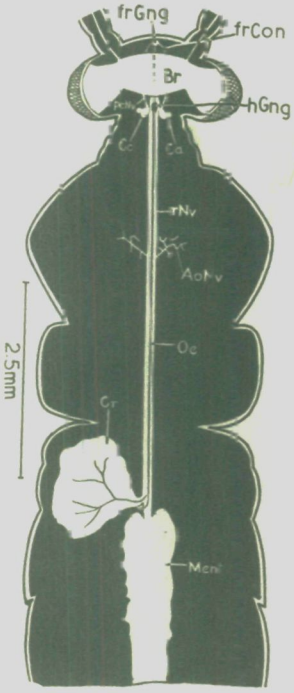
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Oc
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Cr
Mcn
179

PLATE XXV

Pre-imaginal stages and Larval Anatomy.

Fig. 130. Egg.

Fig. 131. Lateral view of the first instar larva.

Fig. 132. Lateral view of the second instar larva.

Fig. 133. Lateral view of the third instar larva.

Fig. 134. Lateral view of the fourth instar larva.

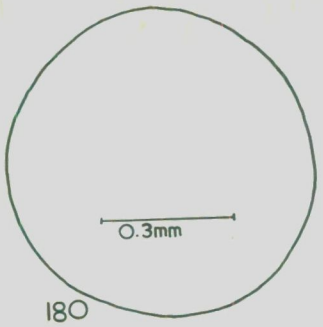
Fig. 135. Lateral view of the fifth instar larva.

Fig. 136. Anterior view of the head of fully grown larva.

Fig. 137. Posterior view of the head capsule.

Fig. 138. Antenna with extrinsic muscle.

PLATE XXV



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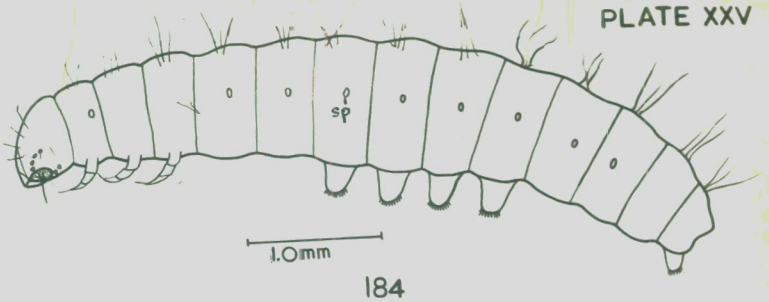

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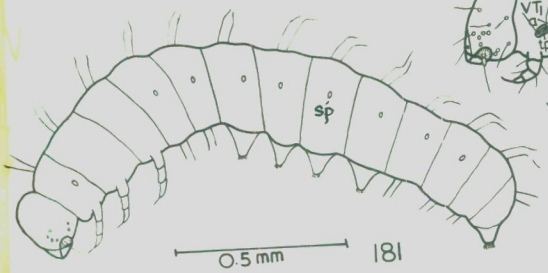

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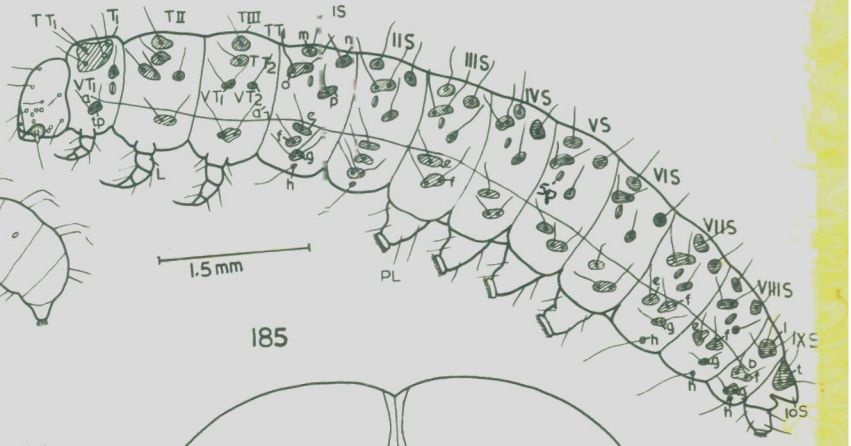

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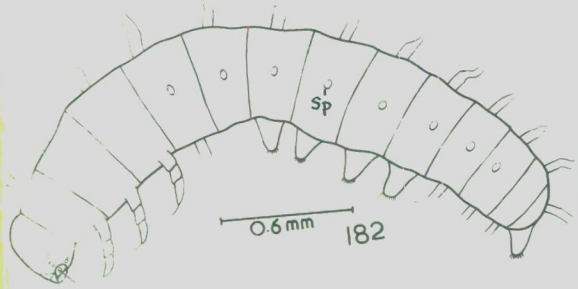

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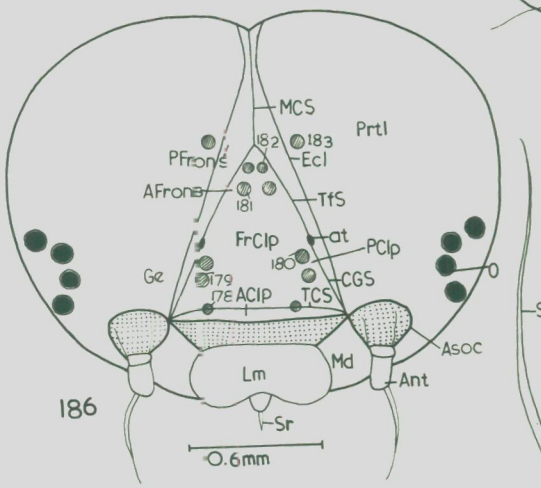

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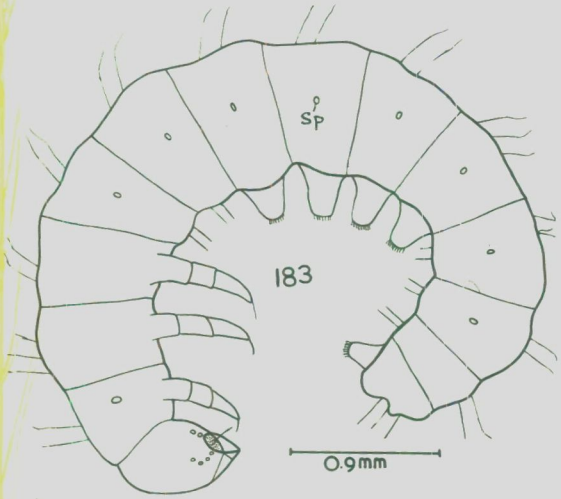

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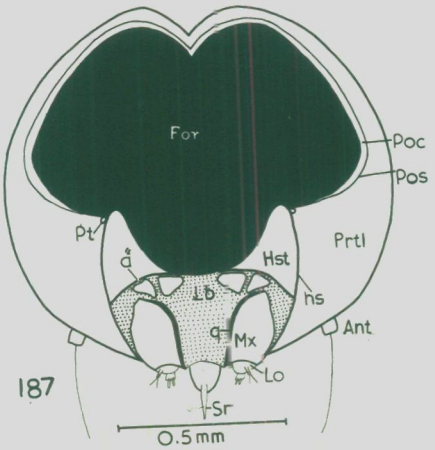

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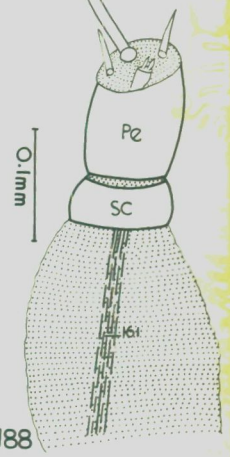

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PLATE XXVI

Larval Anatomy (contd.)

Fig. 189. Mandibles.

Fig. 190. Inner view of the head capsule after removal of its posterior wall showing muscles.

Fig. 191. Ventral view of labio-maxillary-hypopharyngeal complex.

Fig. 192. Inner view of lateral half of the head showing muscles.

Fig. 193. Dorsal view of maxilla with muscles.

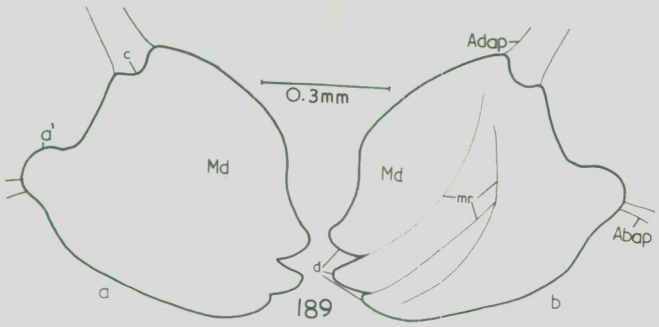
Fig. 194. Lateral view of spinning apparatus.

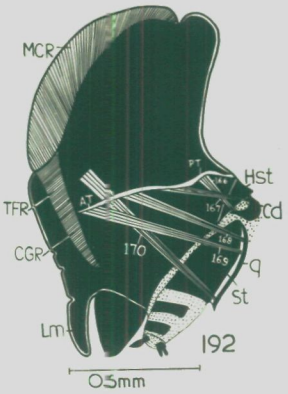
Fig. 195. Inner view of lateral half of spinning apparatus with muscles.

Fig. 196. Inner view of lateral half of head showing muscles.

Fig. 197. Thoracic leg.

PLATE XXVI


Adap
0.3mm
Md
Md
mr
Abap
a
b
189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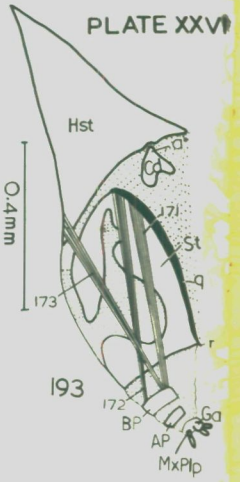
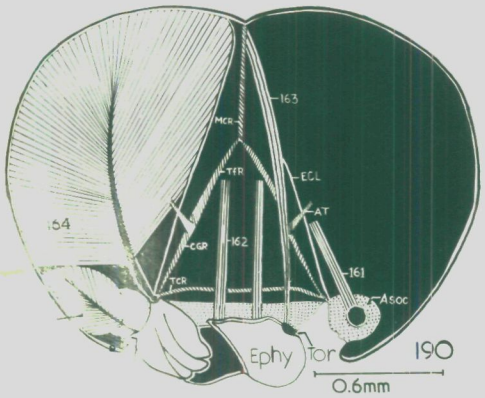
PT
Hst
AT
TFR
Cd
CGR
170
q
St
Lm
192
0.5mm


Hst
0.4mm
171
St
173
q
r
193
172
BP
Ga
AP
MxPlp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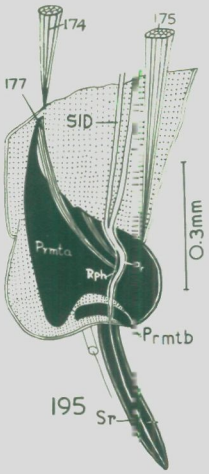
TFR
ECL
AT
164
CGR
162
TCR
161
Asoc
Ephy
Tor
190
0.6mm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175
177
SID
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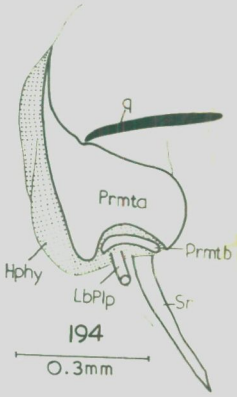
Prmta
Rph
Prmtb
195
Sr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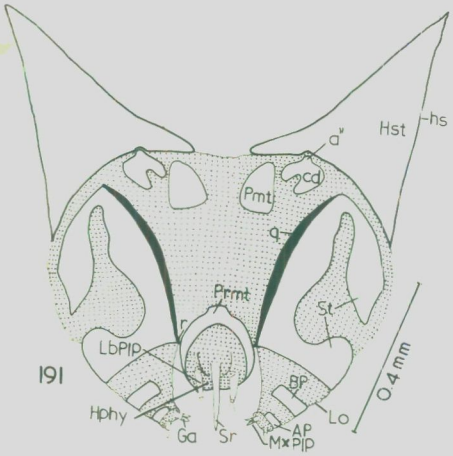
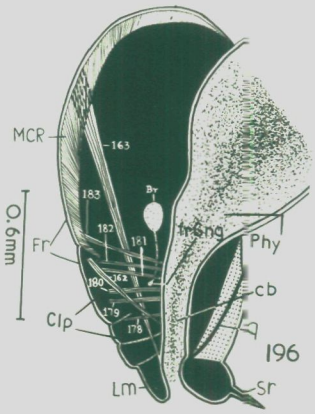
Prmta
Prmtb
Hphy
LbPlp
Sr
194
0.3mm


a''
Hst
hs
cd
Pmt
q
Prmt
St
LbPlp
191
BP
Hphy
Ga
Sr
AP
MxPlp
Lo
0.4mm


MCR
163
Br
183
0.6mm
Fr
182
181
Phy
180
162
cb
179
178
Clp
196
Lm
Sr

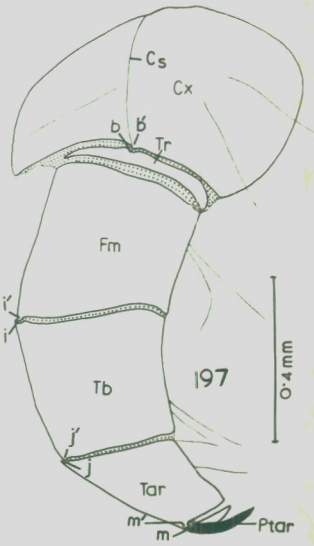

Cs
Cx
b
Tr
Fm
i'
i
0·4mm
Tb
197
j'
j
Tar
m'
m
Ptar

PLATE XXVII

Larval Anatomy and Pre-imaginal stages (contd).

Fig. 198. Prolog.

Fig. 199. Pupa (Ventral view).

G R A P H S.

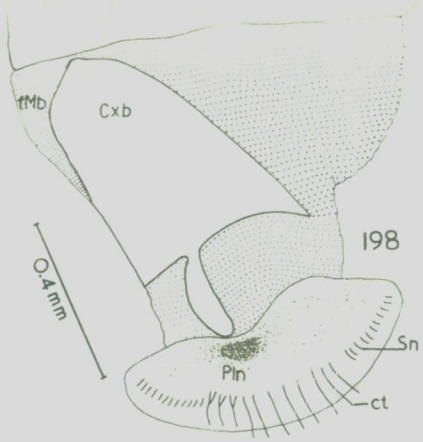
I. Food selection by larva. First Experiment.

II. Food selection by larva. Second Experiment (First stage).

III. Food selection by larva. Second Experiment (Second stage).

IV. Food selection by larva. Second Experiment (Third stage).

PLATE XXVII



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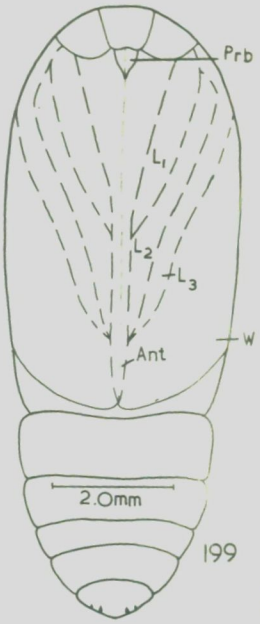

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